PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

FORTY-THIRD SESSION

Vanderbilt University School of Medicine, Nashville, Tennessee, April 14, 15, and 16, 1927

Thursday, April 14, 1927

10.00 a.m. The Forty-third Session of the American Association of Anatomists was called to order by President George L. Streeter, who appointed the following committees:

Committee on Nominations for 1928: Professor Frederic T. Lewis, Chairman; Professor Charles R. Bardeen, and Professor Irving Hardesty.

Auditing Committee: Professor Francis H. Swett, Chairman, and Professor Walter E. Sullivan.

The remainder of the morning session was devoted to the presentation of scientific papers.

Friday, April 15, 1927

12 noon. Association Business Meeting, with President George L. Streeter presiding. The Secretary reported that the minutes for the Forty-second Session were printed in full in The Anatomical Record, volume 32, no. 4, April, 1926, pp. 301–326, inclusive. On motion, seconded and carried, the minutes of the Forty-second Session were approved by the Association as printed in The Anatomical Record.

Report of the Auditing Committee: Professor Francis H. Swett reported for the Auditing Committee as follows: "The undersigned have examined the accounts of the Secretary-Treasurer for the period of December 31, 1925, to December 31, 1926, and have found them to be correct."

[Signed] F. H. Swett,
W. E. Sullivan.

THE ANATOMICAL RECORD, VOL. 35, NO. 2
APRIL, 1927

On motion, the report of the Auditing Committee was accepted and adopted.

Report of the Treasurer: The Treasurer made the following report for the year 1926:

Financial statement for year 1926

Balance on hand, December 31, 1925 (last audit of accounts)		$567.93	
Receipts from dues, 1926		491.04	
Interest on deposits:			
6/29/26	$5.25		
12/29/26	8.37		
		13.62	
Total credits			$1,072.59
Expenditures for 1926:			
Postage		$45.00	
Printing and stationery		71.50	
Expenses of Secretary (New Haven Meeting)		36.82	
Wistar Institute (Abstracts, Anat. Rec.)		62.73	
Wistar Institute (for subscription)		6.50	
Refund for overpayment		1.00	
Secretarial services		51.50	
Total expenditures			275.05
Balance on hand, December 31, 1926			$797.54

Deposited in name of American Association of Anatomists, in Alexander Brown & Sons, Baltimore, Maryland.

On motion, the report of the Treasurer was accepted.

Election of Officers. Professor Eliot R. Clark, Chairman of the Committee on Nominations for 1926, placed before the Association the following nominations for office:

For Members of the Executive Committee with term expiring 1931: Professor Charles H. Danforth and Professor George E. Coghill.

On motion, seconded and carried, the Secretary was instructed to cast a ballot for the election of the above named.

The Secretary informed the Society that the Executive Committee had discussed the selection of members of the Executive Committee on the basis of geographical distribution, as provided for in Article III of the Constitution. No

action was taken by the Society, but the opinion was expressed that in the future attention should be paid by the Nominating Committee to this provision.

New Members. The Secretary presented the following names recommended by the Executive Committee for election to membership in the Association:

ANDERSEN, DOROTHY H., M.D., Assistant in Anatomy, *University of Rochester, School of Medicine, Rochester, N. Y.*

CLARK, SAM L., Ph.D., Assistant Professor of Histology and Neuro-anatomy, *Washington University School of Medicine, St. Louis, Mo.*

COLLINS, HENRY HOMER, Ph.D., Professor of Zoölogy, *University of Pittsburgh, Pittsburgh, Pa.*

COVELL, W. P., Ph.D., Assistant, *Rockefeller Institute for Medical Research, New York City.*

FOLEY, JAMES OWEN, M.S., Ph.D., Instructor in Microscopic Anatomy, *Tulane University of Louisiana, New Orleans, La.*

HANAN, ERNEST B., A.B., A.M., Associate in Anatomy, *University of Buffalo, Buffalo, N. Y.*

HETHERINGTON, DUNCAN CHARTERIS, Ph.D., M.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

HOWELL, A. BRAZIER, A.B., Scientific Assistant, Division of Biological Investigations, *U. S. National Museum, Washington, D. C.*

KAAN, HELEN WARTON, Ph.D., Instructor in Anatomy, *New York University and Bellevue University Medical School, New York City.*

MASON, KARL E., Ph.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

MATTINGLY, MARIE DEES, M.D., Assistant Professor of Anatomy, *Tulane University of Louisiana, New Orleans, La.*

MOSSMAN, HARLAND W., Ph.D., Instructor in Anatomy, *University of Wisconsin, Madison, Wis.*

OBENCHAIN, JEANETTE B., Ph.D., Research Associate, Department of Anatomy, *University of Chicago, Chicago, Ill.*

POLJAK, STEPHEN, M.D., Docent in Neurology, Zagreb University, Jugo-Slavia, *Department of Anatomy, University of Chicago, Chicago, Ill.*

DE RÉNYI, GEORGE ST., M.D., Assistant Professor of Anatomy, *School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

ROGERS, WILLIAM MITCHELL, B.S., Instructor in Histology and Embryology, *Cornell University, Ithaca, N. Y.*

STRAUS, WILLIAM L., JR., Ph.D., National Research Fellow in Anatomy, *Western Reserve University, School of Medicine, Cleveland, Ohio.*

STRONG, LEON H., Ph.D., Assistant Professor of Anatomy, *Indiana University School of Medicine, Bloomington, Ind.*

On motion, seconded and carried, all candidates proposed by the Executive Committee were declared duly elected.

Dropped Members. The Secretary then announced the following names as dropped from the list of members on account of non-payment of dues for the past two years:

Dr. R. B. Green, New Castle on the Tyne, England.
Dr. William A. McIntosh, Oberlin, Ohio.
Dr. K. Nittono, Japan.
Dr. M. D. Ott, Davenport, Iowa.

Death of Members. The Secretary then announced, on behalf of the Executive Committee, that during the past year the Association has suffered great loss in the death of the following active members:

Dr. J. W. Broadnax, Richmond, Va.
Dr. W. F. Campbell, Brooklyn, N. Y.
Dr. G. S. Huntington, New York City.
Dr. H. S. Murphey, Ames, Iowa.

Place of Next Meeting. It was announced that the Executive Committee had decided to hold the Forty-fourth Annual Session of the Association in the Anatomical Laboratory, University of Michigan, Ann Arbor, Michigan, on the days immediately preceding Easter, 1928.

Dues for the Year 1927. The Executive Committee recommended that the dues for the year 1927 be set at $1.00 per member. This recommendation of the Executive Committee was adopted by the Association.

Payment to Local Committee. On recommendation of the Executive Committee, it was moved and seconded that $100.00 be paid from the funds of the Association to the Local Committee on Arrangements of Vanderbilt University, to be used in connection with the entertainment of the Association during the present meeting. On vote of the Association, the motion was lost.

It was moved, seconded, and carried that the Association declare its intention of paying the sum of $100.00 annually from the general funds of the Association to the Local Committee on Arrangements during the meetings.

Report of the Journal Committee. In the absence of Professor Frederic T. Lewis, Chairman, the Secretary laid

before the Association the Report of the Journal Committee for the year 1926. The Journal Committee recommended unanimously that the Committee be discontinued, inasmuch as its only remaining functions are the preparation of an annual report and the occasional selection of a managing editor for the journals. It was further recommended in the report that the functions of the Journal Committee be discharged in the future by the Executive Committee of the Association.

The Secretary informed the Society that the Executive Committee had considered the matter and had unanimously voted in favor of the recommendations.

It was moved, seconded, and carried that the Report of the Journal Committee be accepted, the recommendations of the Committee be placed in effect, and the Secretary be instructed to convey to the members of the Journal Committee the formal thanks of the Association for the services rendered.

Terms of Office of Executive Committee. The Secretary pointed out that the present Forty-third Session of the Association represents a meeting which should have been held at Christmas, 1926, and that the terms of office of the two senior members of the Executive Committee ended in 1926. On recommendation of the Executive Committee, it was moved, seconded, and carried that the Secretary be authorized to alter the dates of terms of office of all members of the Executive Committee to coincide with the present custom of holding the annual session in the spring of each year.

On motion, the business session then adjourned.

Saturday, April 16, 1927

12.45 p.m. Concluding business session. A short business meeting followed the morning scientific session. The Secretary reported that there was no unfinished business.

Resolution regarding the Death of Professor George S. Huntington. In the absence of Professor R. J. Terry, the Secretary presented the following resolution, which had been prepared by Professor Terry:

In the year 1892, this Association elected to membership Dr. George Sumner Huntington, Professor of Anatomy in the College of Physicians and Surgeons, New York, whose lamented death occurred January 5th of the present year. During a long period, and until recently when illness had disabled him, Doctor Huntington gave to this Association, untiringly and to his utmost, wise counsel and generous cooperation, and presented always the example of an indefatigable investigator and inspiring teacher. His life was devoted to the development of morphological science and his influence has been felt in the important advances of this and allied branches of biology during the past quarter-century; his name is connected with the significant steps of progress in morphology taken in America. The effect of the loss of so forceful a scholar will be widespread; it is most deeply felt by this Association of his colleagues. We are moved, therefore, to pause in the course of the scientific program of this, the forty-third meeting of the American Association of Anatomists, following so close upon the passing of Doctor Huntington, and to recall his kind and stimulating personality, to deplore the loss of his leadership, and to avow the benefits of his contribution to science and humanity.

On motion, duly seconded, it was voted to spread the above resolution on the minutes of the Association, and the Secretary was instructed to send a copy of the resolution to Doctor Huntington's family.

Resolution of Appreciation. Professor Herbert M. Evans presented the following resolution:

Resolved: That we, the American Association of Anatomists, in Forty-third Session assembled, desire to express to the authorities of Vanderbilt University, its Faculty of Medicine, and our colleagues in the Department of Anatomy our warm appreciation of the signal hospitality with which our sessions have been welcomed. We would also particularly bespeak gratification at the remarkable material appointments and guiding conceptions of education and research which constitute the School of Medicine of this Institution.

We watch with sympathy and with interest the purposeful effort here and elsewhere to interrelate physically and spiritually the clinic and the laboratory and especially the various medical sciences, not forgetting, however, that many of the achievements of modern medicine have emanated from autonomous departments, divisions, or institutes which have been privileged to enjoy independence in viewpoint and in scientific interest.

Moved, seconded, and unanimously voted.

On motion, the Session adjourned.

LEWIS H. WEED,
Secretary of the Forty-third Session of the American Association of Anatomists.

AMERICAN ASSOCIATION OF ANATOMISTS

OFFICERS AND LIST OF MEMBERS

Officers

President.....George L. Streeter
Vice-President.....Stephen W. Ranson
Secretary-Treasurer.....Lewis H. Weed

Executive Committee

For term expiring 1928.....Charles R. Stockard, Clarence M. Jackson
For term expiring 1929.....J. Parsons Schaeffer, T. Wingate Todd
For term expiring 1930.....George W. Corner, Edmund V. Cowdry
For term expiring 1931.....Charles H. Danforth, George E. Coghill

Delegates to the Council of A. A. A. S.

J. Playfair McMurrich
Harold D. Senior

Representative to the National Research Council

George L. Streeter

Committee on Nominations for 1928

Frederic T. Lewis, *Chairman*
Charles R. Bardeen Irving Hardesty

Honorary Members

S. Ramón y Cajal.....*Madrid, Spain*
A. Nicolas.....*Paris, France*

MEMBERS

ABBOTT, MAUDE E., A.B., C.M., M.D., F.R.C.P.& S., Assistant Professor of Research Medicine, McGill University, *836 University St., Montreal, Canada.*

DE ABERLE, (MRS.) SOPHIE B., A.B., A.M., Research Assistant in Anthropology, *Kent Hall, Yale University, New Haven, Conn.*

ADAMS, A. ELIZABETH, A.B., A.M., Ph.D., Associate Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

ADAMS, L. A., A.B., A.M., Ph.D., Assistant Professor of Zoölogy, *University of Illinois, 605 West Indiana St., Urbana, Ill.*

ADDISON, WILLIAM HENRY FITZGERALD, B.A., M.D., Professor of Normal Histology and Embryology, *School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

ADELMANN, HOWARD B., B.A., M.A., Ph.D., Assistant Professor of Histology and Embryology, *Cornell University, Stimson Hall, Ithaca, N. Y.*

ALFORD, LELAND BARTON, A.B., M.D., Associate in Clinical Neurology, Washington University School of Medicine, *Humboldt Building, St. Louis, Mo.*

ALLEN, BENNET MILLS, Ph.D., Professor of Zoölogy, University of California (Southern Branch), *909 Micheltorena St., Los Angeles, Calif.*

ALLEN, EDGAR, A.M., Ph.D., Professor of Anatomy, *University of Missouri, Columbia, Mo.*

ALLEN, EZRA, A.M., Ph.D., Professor of Biology, *Ursinus College, Collegeville, Pa.*

ALLEN, WILLIAM F., A.M., Ph.D., Professor of Anatomy, *University of Oregon Medical School, Portland, Oregon.*

ALLIS, EDWARD PHELPS, JR., C.E., M.D., LL.D., *Palais de Carnoles, Menton (A.M.), France.*

ANDERSEN, DOROTHY H., M.D., Assistant in Anatomy, *University of Rochester, School of Medicine, Rochester, N. Y.*

ANSON, BARRY J., A.B., A.M., Medical Fellow of the National Research Council and Fellow in Histology, *Northwestern University Medical School, Chicago, Ill.*

APPLEBY, J. I., A.B., M.B., A.M., M.D., *105½ East Main St., Bellevue, Ohio.*

ARAI, HAYATO, M.D., Chief Gynecologist, *Sapporo Hospital, Sapporo, Japan.*

ARATAKI, MINORU, *Director Arataki Hospital, Asahigawa, Japan.*

AREY, LESLIE B., Ph.D., Robert Laughlin Rea Professor of Anatomy, and Chairman of the Division of Anatomy, *Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

ATTERBURY, RUTH RAND, A.M., Ph.D., *144 Overlook Ave., Great Neck, L. I.*

ATWELL, WAYNE JASON, A.M., Ph.D., Professor of Anatomy, University of Buffalo Medical College, *24 High St., Buffalo, N. Y.*

BADERTSCHER, JACOB A., Ph.D., Professor of Anatomy, Indiana University School of Medicine, *312 South Fess Ave., Bloomington, Ind.*

BAGLEY, CHARLES, JR., M.D., *The Latrobe Apts., Baltimore, Md.*

BAILEY, PERCIVAL, M.D., Ph.D., Instructor in Surgery, *Harvard Medical School, Boston, Mass.*

BAITSELL, GEORGE ALFRED, B.S., M.A., Ph.D., Associate Professor of Biology, Yale University, *Osborn Zoölogical Laboratory, New Haven, Conn.*

BALDWIN, WESLEY MANNING, A.B., A.M., M.D., Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

BARDEEN, CHARLES RUSSELL, A.B., M.D. (Ex. Com. '06–'09, Vice-President '18–'20), Professor of Anatomy and Dean of Medical School, *University of Wisconsin, Science Hall, Madison, Wis.*

BARTA, EDMUND, M.D., Adjunct, Department of Anatomy, *Royal University Medical School, Budapest, Hungary.*

BARTELMEZ, GEORGE W., Ph.D., Associate Professor of Anatomy, *University of Chicago, Chicago, Ill.*

BARTSCH, PAUL, A.B., M.S., Ph.D., Curator, Division of Mollusks, *U. S. National Museum, Washington, D. C.*

BASCOM, KELLOGG F., B.A., M.S., Ph.D., Associate Professor, *Department of Anatomy, Medical College of Virginia, Richmond, Va.*

BAST, T. H., B.A., Ph.D., Associate Professor of Anatomy, *University of Wisconsin, 308 Science Hall, Madison, Wis.*

BATSON, O. V., A.M., M.D., Associate Professor of Anatomy, *College of Medicine, Cincinnati University, Eden Ave., Cincinnati, Ohio.*

BAUMGARTNER, WILLIAM J., A.B., A.M., Professor of Zoölogy, University of Kansas, *1209 Ohio St., Lawrence, Kans.*

BAYON, HENRY, B.A., M.D., Professor of Applied Anatomy, Tulane University, *2212 Napoleon Ave., New Orleans, La.*

BEAN, ROBERT BENNETT, B.S., M.D., Professor of Anatomy, University of Virginia, *5 Wayside Place, University, Va.*

BEGG, ALEXANDER S., B.S., M.D., Professor of Anatomy and Dean, Boston University School of Medicine, *80 East Concord St., Boston, Mass.*

BENSLEY, ROBERT RUSSELL, A.B., M.B., Sc.D. (Second Vice-Pres. '06–'07, Ex. Com. '08–'12, President '18–'20), Professor of Anatomy, Director of Hull Laboratory of Anatomy, *University of Chicago, Chicago, Ill.*

BEVAN, ARTHUR DEAN, M.D. (Ex. Com. '96–'98), Professor of Surgery, University of Chicago, *122 South Michigan Blvd., Chicago, Ill.*

BIGELOW, ROBERT P., S.B., Ph.D., Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Cambridge 39, Mass.*

BISHOP, KATHERINE SCOTT, A.B., M.D., Histologist, Hooper Research Institute, San Francisco, *1508 La Loma Ave., Berkeley, Calif.*

BLACK, DAVIDSON, B.A., M.B., Professor of Anatomy, *Peking Union Medical College, Peking, China.*

BLAIR, VILRAY PAPIN, A.M., M.D., Associate in Clinical Surgery, Washington University School of Medicine, *Metropolitan Building, St. Louis, Mo.*

BLAISDELL, FRANK ELLSWORTH, SR., M.D., Professor of Surgery, Medical Department of Stanford University, *1520 Lake St., San Francisco, Calif.*

BLAKE, J. A., A.B., Ph.B., M.A., M.D., F.A.C.S., Consulting Surgeon, St. Luke's, Roosevelt, Orthopedic, Lincoln, Dobbs Ferry, St. John's (Yonkers), *Tarrytown Hospitals, Tarrytown, N. Y.*

BOYDEN, EDWARD ALLEN, A.M., Ph.D., Associate Professor of Anatomy, *University of Illinois, College of Medicine, Chicago, Ill.*

BREMER, JOHN LEWIS, A.B., M.D. (Ex. Com. '15–'18), Associate Professor of Histology, *Harvard Medical School, Boston, Mass.*

BROWNING, WILLIAM, Ph.B., M.D., Professor of Neurology, Long Island College Medical School, *54 Lefferts Place, Brooklyn, N. Y.*

Bryce, Thomas H., M.A., M.D., F.R.S., Professor of Anatomy, University of Glasgow, *No. 2, The University, Glasgow, Scotland.*

Bullard, H. Hays, A.M., Ph.D., M.D., Professor of Pathology, *Western University Medical School, London, Ontario, Canada.*

Bunting, Charles Henry, B.S., M.D., Professor of Pathology, *University of Wisconsin, Madison, Wis.*

Burns, B. I., M.D., Professor of Anatomy and Head of Department, *University of Utah, School of Medicine, Salt Lake City, Utah.*

Burr, Harold Saxton, Ph.D., Associate Professor of Anatomy, School of Medicine, Yale University, *333 Cedar St., New Haven, Conn.*

Burrows, Montrose T., A.B., M.D., Associate Professor of Experimental Surgery, Director of Research Laboratories, Barnard Free Skin and Cancer Hospital, *Washington University Medical School, St. Louis, Mo.*

Butler, Elmer G., A.B., Ph.D., Instructor in Comparative Anatomy, *Department of Biology, Princeton University, Princeton, N. J.*

Cairney, John, M.B., Ch.B., M.D., Associate Professor of Anatomy, *Department of Anatomy, University of Otago, Dunedin, New Zealand.*

Calkins, Leroy A., B.S., M.S., M.B., M.D., Ph.D., Professor of Obstetrics and Gynecology, University of Virginia Medical School, *Box 238, University, Va.*

Cameron, Angus L., A.B., M.S., M.D., Ph.D., *128 South Main St., Minot, N. Dak.*

Cameron, John, M.D., D.Sc., F.R.S.E., Professor of Anatomy, *Dalhousie Medical College, Halifax, Nova Scotia.*

Cardwell, John C., M.D., Professor of Physiology, Long Island College Hospital, *Polhemus Memorial Clinic, Brooklyn, N. Y.*

Carey, Eben J., M.S., Sc.D., Acting Dean of Students, Professor of Anatomy, Marquette University School of Medicine, *638 Fourth St., Milwaukee, Wis.*

Carver, Gail L., A.B., A.M., *613 Orange St., Macon, Ga.*

Casamajor, Louis, A.M., M.D., Professor of Neurology, Columbia University, *437 West Fifty-ninth St., New York City.*

Chagas, Carlos P., M.D., Professor of Histology and Pathology, *Bello Horizonte Medical School, Minas-Geraes, Rua Tymbiras 1490, Brazil, South America.*

Chambers, Robert, Jr., A.M., Ph.D., Professor of Microscopic Anatomy, *Cornell University Medical College, New York City.*

Chang, Chun, M.D., Professor of Anatomy, *Hopei University, Paotingfu, Chihli, China.*

Charlton, Harry Hayward, A.B., A.M., Ph.D., Associate Professor of Anatomy, *Department of Anatomy, University of Missouri, Columbia, Mo.*

Chase, Samuel Wood, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, *Western Reserve University School of Medicine, 2109 Adelbert Road, Cleveland, Ohio.*

Chidester, Floyd E., A.M., Ph.D., Professor of Zoölogy, *University of West Virginia, Morgantown, W. Va.*

Child, Charles Manning, M.S., Ph.D., Professor of Zoölogy, *Zoölogical Laboratory, University of Chicago, Chicago, Ill.*

Chillingworth, Felix P., M.D., Professor of Physiology and Experimental Pharmacology, Tufts Medical College, *416 Huntington Ave., Boston, Mass.*

Chouke, Kehar Singh, M.D., Instructor in Anatomy, *Colorado University Medical School, 4200 East Ninth Ave., Denver, Colo.*

CLARK, ELEANOR LINTON, A.M., Voluntary Research Worker, Department of Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

CLARK, ELIOT R., A.B., M.D., (Ex. Com. '16–'19), Professor of Anatomy and Director of Department of Anatomy, University of Pennsylvania, *301 St. Mark's Square, Philadelphia, Pa.*

CLARK, SAM L., Ph.D., Assistant Professor of Histology and Neuro-anatomy, *Washington University School of Medicine, St. Louis, Mo.*

COE, WESLEY R., Ph.D., *175 Bishop St., New Haven, Conn.*

COGHILL, GEORGE E., A.B., M.S., Ph.D., (Ex. Com. '27–), Professor of Comparative Anatomy, *The Wistar Institute of Anatomy and Biology, Woodland Ave. and Thirty-sixth St., Philadelphia, Pa.*

COHN, ALFRED E., A.B., M.D., Member, *Rockefeller Institute for Medical Research, New York City, N. Y.*

COLLINS, HENRY HOMER, Ph.D., Professor of Zoölogy, *University of Pittsburgh, Pittsburgh, Pa.*

COMAN, FRANCIS DANA, A.B., A.M., M.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

CONANT, WILLIAM MERRITT, A.B., M.D., Professor of Clinical Surgery, *636 Beacon St., Boston, Mass.*

CONEL, JESSE LEROY, A.M., Ph.D., Professor of Anatomy, Boston University School of Medicine, *80 E. Concord St., Boston, Mass.*

CONGDON, EDGAR DAVIDSON, Ph.D., Professor of Anatomy, *Chulalongkorn University Medical School, Bangkok, Siam.*

CONKLIN, EDWIN GRANT, A.M., Ph.D., Sc.D., L.L.D., Professor of Biology, Princeton University, *139 Broadmead Ave., Princeton, N. J.*

COPENHAVER, WILFRED M., A.B., Ph.D., Instructor in Anatomy, *University of Rochester, School of Medicine, Rochester, N. Y.*

CORNER, GEORGE W., A.B., M.D., (Ex. Com. '26–), Professor of Anatomy, *University of Rochester, Rochester, N. Y.*

CORNING, H. K., M.D., Professor of Anatomy, *University of Bâle, Anatomische Anstalt, Bâle, Switzerland.*

COVELL, W. P., Ph.D., Assistant, *Rockefeller Institute for Medical Research, New York City.*

COWDRY, EDMUND V., Ph.D. (Ex. Com. '26–), Associate Member, *Rockefeller Institute for Medical Research, Ave. A and Sixty-sixth St., New York City.*

CRAIGIE, E. HORNE, B.A., Ph.D., Assistant Professor of Comparative Anatomy and Neurology, *Department of Biology, University of Toronto, Toronto, 5, Canada.*

CRILE, GEORGE W., A.M., M.D., LL.D., F.A.C.S., Professor of Surgery, Western Reserve University, *Cleveland Clinic, 93rd and Euclid, Cleveland, Ohio.*

CROSBY, ELIZABETH CAROLINE, M.S., Ph.D., Assistant Professor of Anatomy, University of Michigan, *420 Maynard St., Ann Arbor, Mich.*

CULLEN, THOMAS S., M.B., Professor of Clinical Gynecology, Johns Hopkins University, *20 E. Eager St., Baltimore, Md.*

CUMMINS, HAROLD, A.B., Ph.D., Associate Professor of Anatomy, *Tulane University Medical School, Department of Anatomy, Sta. 20, New Orleans, La.*

CUNNINGHAM, ROBERT S., A.M., M.D., Professor of Anatomy, *Vanderbilt School of Medicine, Nashville, Tenn.*

CURTIS, GEORGE M., A.M., Ph.D., M.D., Associate Professor of Surgery, *12 Ziegler-strasse, Berne, Switzerland.*

DAHLGREN, ULRIC, A.B., M.S., Professor of Biology, Princeton University, *204 Guyot Hall, Princeton, N. J.*

DANCHAKOFF, VERA, M.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *437 W. Fifty-ninth St., New York City.*

DANFORTH, CHARLES HASKELL, A.M., Ph.D., (Ex. Com. '27–), Professor of Anatomy, Leland Stanford University, *Stanford University, Calif.*

DARRACH, WILLIAM, A.B., A.M., M.D., Professor of Clinical Surgery and Dean of Faculty of Medicine, College of Physicians and Surgeons, Columbia University, *437 West Fifty-ninth St., New York City.*

DART, RAYMOND A., M.B., Ch.M., M.Sc., Professor of Anatomy, *University of the Witwatersrande, Johannesburg, Transvaal, South Africa.*

DAVIS, CARL L., M.D., Professor of Anatomy, *Medical Dept., University of Maryland, Baltimore, Md.*

DAVIS, WARREN B., M.D., F.A.C.S., Instructor in Anatomy, Jefferson Medical College, *135 S. 18th St., Philadelphia, Pa.*

DAWSON, ALDEN B., A.B., Ph.D., Associate Professor of Biology, *Department of Biology, New York University, University Heights, N. Y.*

DEAN, BASHFORD, A.B., A.M., Ph.D., Professor of Vertebrate Zoölogy, Columbia University, Curator of Fishes and Reptiles, American Museum Natural History, *Riverdale-on-Hudson, New York City.*

DE CARLO, JOHN, M.D., Demonstrator of Topographic and Applied Anatomy, Jefferson Medical College, *1629 S. Broad St., Philadelphia, Pa.*

DEGARIS, CHARLES F., A.B., M.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

DETWILER, SAMUEL RANDALL, A.M., Ph.D., Associate Professor of Zoölogy, *Zoölogical Laboratory, Harvard University, Cambridge, Mass.*

DIXON, A. FRANCIS, M.B., Sc.D., University Professor of Anatomy, Trinity College, *42 Elgin Road, Dublin, Ireland.*

DOAN, CHARLES A., A.B., M.D., Associate, *Rockefeller Institute for Medical Research, Sixty-sixth St. and Avenue A, New York City.*

DODDS, GIDEON S., A.M., Ph.D., Professor of Histology and Embryology, *West Virginia University Medical School, Morgantown, W. Va.*

DODSON, JOHN MILTON, A.M., M.D., Professor (Emeritus) of Medicine, *Rush Medical College, 5707 Blackston Ave., Chicago, Ill.*

DOLLEY, D. H., A.B., A.M., M.D., Professor of Pathology, University of Missouri, *1402 S. Grand Ave., St. Louis, Mo.*

DONALDSON, HENRY HERBERT, Ph.D., D.Sc. (Ex. Com. '09–'13, Pres. '16–'17), Professor of Neurology, *The Wistar Institute of Anatomy and Biology, Woodland Ave. and 36th St., Philadelphia, Pa.*

DONALDSON, JOHN C., Ph.B., M.D., Associate Professor of Anatomy, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

DOWNEY, HAL, A.M., Ph.D., Professor of Histology, *Department of Animal Biology, University of Minnesota, Minneapolis, Minn.*

DUESBERG, JULES, M.D., Professor of Anatomy, *University of Liege, 22 quai Mativa, Liege, Belgium.*

DUNN, ELIZABETH HOPKINS, A.M., M.D., In charge of the Memorial Funds for the Study of the Nervous System, *Woods Hole, Mass.*

DUNN, H. L., M.A., B.A., M.B., Ph.D., M.D., Associate Professor of Biometry and Vital Statistics, *Department of Biometry, School of Hygiene, Johns Hopkins University, Baltimore, Md.*

EATON, PAUL BARNES, A.B., M.D., Treasury Dept., *Quarantine Station, Gallops Island, Boston, Mass.*

ECCLES, ROBERT G., M.D., Phar.D., *681 Tenth St., Brooklyn, N. Y.*

ELWYN, ADOLPH, A.M., Assistant Professor of Anatomy, Columbia University, *437 W. 59th St., New York City.*

EMMEL, VICTOR E., B.S., M.S., Ph.D., Professor of Anatomy, *Department of Anatomy, University of Illinois, 1817 W. Polk St., Chicago, Ill.*

ENGLE, EARL THERON, A.B., A.M., Ph.D., Instructor, *Department of Anatomy, Stanford University, California.*

ESSICK, CHARLES RHEIN, B.A., M.D., *520 Franklin St., Reading, Pa.*

EVANS, HERBERT MCLEAN, B.S., M.D. (Ex. Com. '19–'22), Professor of Anatomy, *University of California, Berkeley, Calif.*

EVANS, THOMAS HORACE, M.D., Associate Professor of Anatomy, Long Island College Hospital, *Room 83, Polhemus Memorial, Brooklyn, N. Y.*

FARIS, HERVEY S., A.B., A.M., Ph.D., Instructor in Anatomy, *Loyola University School of Medicine, 5525 Kimbark Ave., Chicago, Ill.*

FERRIS, HARRY BURR, A.B., M.D., Hunt Professor of Anatomy, Medical Department, Yale University, *395 St. Ronan St., New Haven, Conn.*

FETTEROLF, GEORGE, A.B., M.D., Sc.D., Professor of Oto-laryngology, University of Pennsylvania, *2010 Spruce St., Philadelphia, Pa.*

FISCHELIS, PHILIP, M.D., Professor of Histology and General Pathology, Philadelphia Dental College of Temple University, *2132 N. 19th St., Philadelphia, Pa.*

FLORENCE, LAURA, B.Sc., M.A., Ph.D., Assistant Professor of Histology and Embryology, *New York Homeopathic Medical College, Sixty-fourth St. and Avenue A, New York City.*

FOLEY, JAMES OWEN, M.S., Ph.D., Instructor in Microscopic Anatomy, *Tulane University of Louisiana, New Orleans, La.*

FORMAN, JONATHAN, A.B., M.D., *394 East Town St., Columbus, Ohio.*

FOSTER, WILMOT COYNE, A.B., A.M., M.D., Assistant Professor of Anatomy, *University of Oregon Medical School, Portland, Ore.*

FRASSETTO, FABIO, Ph.D., Director Anthropological Institute, *University of Bologna, Bologna, Italy.*

FRAZER, JOHN ERNEST, M.D., F.R.C.S., Professor of Anatomy, University of London, *St. Mary's Hospital Medical School, London, W., England.*

FRENCH, H. E., M.S., M.D., Professor of Anatomy and Dean of the School of Medicine, *University of North Dakota, Grand Forks, North Dakota.*

GAGE, SIMON HENRY, B.S. (Ex. Com. '06–'11), Professor of Histology and Embryology, Emeritus, *Stimson Hall, Cornell University, Ithaca, N. Y.*

GALLAUDET, BERN BUDD, A.B., A.M., M.D., Assistant Professor of Anatomy, Columbia University, Consulting Surgeon, Bellevue Hospital, *26 Gramercy Park, New York City.*

GAMBLE, DEAN L., B.S., Ph.D., Assistant Professor of Zoölogy, *Cornell University, McGraw Hall, Ithaca, N. Y.*

GARCIA, ARTURO, A.B., M.D., Professor of Anatomy, *College of Medicine and Surgery, 619 Colorado St., Manila, Philippine Islands.*

GEIST, FREDERICK D., M.D., Assistant Professor of Anatomy, *University of Wisconsin, Science Hall, Madison, Wis.*

GEORGE, WESLEY CRITZ, A.B., A.M., Ph.D., Professor of Histology and Embryology, *University of North Carolina Medical School, Chapel Hill, N. C.*

GILLASPIE, C., M.D., F.A.C.S., Associate Professor of Anatomy, *University of Colorado, Boulder, Colo.*

GLOBUS, J. H., B.S., M.D., Assistant Professor of Neuro-anatomy, New York University and Bellevue Medical College, *1075 Park Ave., New York City.*

GOULD, HARLEY NATHAN, A.B., A.M., Ph.D., Professor of Biology, *Newcomb College, Tulane University, New Orleans, La.*

GRANT, J. C. BOILEAU, M.D., Ch.B., F.R.C.S., Professor of Anatomy, *University of Manitoba Medical College, Winnipeg, Canada.*

GRAVES, WILLIAM W., M.D., Professor of Nervous and Mental Diseases, St. Louis University School of Medicine, *5136 Enright Ave., St. Louis, Mo.*

GREENE, CHARLES W., A.M., Ph.D., Professor of Physiology and Pharmacology, University of Missouri, *814 Virginia Ave., Columbia, Mo.*

GREENE, WALTER FARRAR, A.B., Ph.D., Assistant Professor of Anatomy, *University of Buffalo, Buffalo, N. Y.*

GREENHILL, J. P., B.S., M.D., Attending Obstetrician, The Chicago Lying-in-Hospital, Instructor in Obstetrics, Northwestern Medical School, *426 East Fifty-first St., Chicago, Ill.*

GREENMAN, MILTON J., Ph.B., M.D., Sc.D., Director of *The Wistar Institute of Anatomy and Biology, 36th St. and Woodland Ave., Philadelphia, Pa.*

GREGORY, WILLIAM KING, A.B., A.M., Ph.D., Professor of Vertebrate Palaeontology, Columbia; Associate in Vertebrate Palaeontology, American Museum of Natural History, and Curator of Comparative Anatomy, *American Museum of Natural History, 136 West 77th St., New York City.*

GUDERNATSCH, J. F., Ph.D., *19 Cliff St., New York City.*

GUILD, STACY R., A.M., Ph.D., Associate Professor of Anatomy, Medical School, University of Michigan, *562 South Seventh St., Ann Arbor, Mich.*

GURDJIAN, ELISHA STEPHENS, A.B., M.S., M.D., Instructor in Anatomy, *Department of Anatomy, University of Michigan, Ann Arbor, Michigan.*

GUTTMACHER, ALAN F., A.B., M.D., Instructor in Obstetrics, *Johns Hopkins Hospital, Baltimore, Md.*

GUYER, MICHAEL F., Ph.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

HALPERT, BÉLA, M.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HAMANN, CARL A., M.D. (Ex. Com. '02–'04), Professor of Applied Anatomy and Clinical Surgery, Western Reserve University, *416 Osborne Building, Cleveland, Ohio.*

HANAN, ERNEST B., A.B., A.M., Associate in Anatomy, *University of Buffalo, Buffalo, N. Y.*

HANSON, FRANK BLAIR, A.B., A.M., Ph.D., Professor of Zoölogy, *Washington University, St. Louis, Mo.*

HARDESTY, IRVING, A.B., Ph.D., Sc.D. (Ex. Com. '10 and '12–'15, '22–'23), Professor of Anatomy and Head of Department of Anatomy, School of Medicine, *Tulane University, P. O. Station 20, New Orleans, La.*

HARE, EARL R., A.B., M.D., F.A.C.S., *730 LaSalle Building, Minneapolis, Minn.*

HARGITT, GEORGE T., Professor of Zoölogy, Lyman Hall, *Syracuse University, Syracuse, N. Y.*

HARRIS, HENRY A., M.B., B.S., F.Z.S., M.R.C.S., L.R.C.P., Senior Demonstrator of Anatomy, Curator of the Museum of Anatomy, *University College, Gower St., London, W.C.1, England.*

HARRISON, ROSS GRANVILLE, Ph.D., M.D., Sc.D. (Pres. '12–'14), Bronson Professor of Comparative Anatomy, *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

HARTMAN, CARL G., Ph.D., *Carnegie Laboratory of Embryology, Johns Hopkins Medical School, Baltimore, Md.*

HARVEY, BASIL COLEMAN HYATT, A.B., M.B., Professor of Anatomy and Dean of Medical Students, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*

HARWELL, CHAS. W., A.B., M.D., Assistant Professor of Anatomy, *Emory University, Emory, Ga.*

HATAI, SHINKISHI, Ph.D., Professor of Neurology, *c/o Tohoku Imperial University, Sendai, Japan.*

HAUSMAN, LOUIS, A.B., M.D., Instructor in Psychiatry, *1175 Park Avenue, New York City.*

HAZEN, CHARLES MORSE, A.M., M.D., *Professional Building, Fifth and Franklin Sts., Richmond, Va.*

HEISLER, JOHN C., M.D., Professor of Anatomy, University of Pennsylvania, *3829 Walnut St., Philadelphia, Pa.*

HELDT, THOMAS JOHANES, A.B., A.M., M.D., Physician in Charge of Neuropsychiatric Division, *Henry Ford Hospital, Detroit, Mich.*

HEMLER, WILLIAM FRANCIS, M.D., Professor of Roentgenology, Georgetown University, *1330 East Capitol St., Washington, D. C.*

HERRICK, CHARLES JUDSON, Ph.D. (Ex. Com. '13–'17), Professor of Neurology, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*

HERTZLER, ARTHUR E., B.S., A.M., Ph.D., M.D., LL.D., F.A.C.S., Professor of Surgery, *University of Kansas, Halstead, Kansas.*

HETHERINGTON, DUNCAN CHARTERIS, Ph.D., M.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

HEUSER, CHESTER H., A.M., Ph.D., Research Associate, Department of Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

HEWSON, ADDINELL, A.B., A.M., M.D., F.A.C.S., Professor of Anatomy, Graduate School of Medicine, University of Pennsylvania, Professor of Anatomy and Histology, Temple University, *257 South 16th St., Philadelphia, Pa.*

HIGGINS, GEORGE M., A.M., Ph.D., Assistant in Experimental Surgery, *Mayo Foundation, Rochester, Minn.*

HILL, EBEN CLAYTON, A.B., M.D., Lecturer in Roentgenological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HILL, HOWARD, M.D., *734 Argyle Building, Kansas City, Mo.*

HILL, JAMES PETER, D.Sc., F.R.S., Professor of Embryology, University of London, *University College, Gower St., London., W. C. 1, England.*

HILTON, WILLIAM A., B.S., Ph.D., Professor of Zoölogy, Pomona College, Director *Laguna Marine Laboratory, Claremont, Calif.*

HINES-LOEB, MARION, A.B., Ph.D., Associate in Anatomy, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HOFFMAN, CLARENCE, M.D., Associate in Anatomy, Jefferson Medical College, *1630 Pine St., Philadelphia, Pa.*

HOGUE, MARY J., Ph.D., Instructor in Normal Histology, *University of Pennsylvania Medical School, Philadelphia, Pa.*

HOLMGREN, NILS, M.D., Professor of Zoölogy, *University of Stockholm, Sweden.*

HOLT, CAROLINE M., A.B., A.M., Ph.D., Assistant Professor of Biology, Simmons College, *101 St. Paul St., Brookline, Mass.*

HOOKER, DAVENPORT, M.A., Ph.D. (Ex. Com. '22–'25), Professor of Anatomy, *School of Medicine, University of Pittsburgh, Oakland Station, Pittsburgh, Pa.*

HOPKINS, GRANT SHERMAN, Sc.D., D.V.M., Professor Comparative Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*

HOSKINS, MARGARET MORRIS, Ph.D., Assistant Professor of Microscopic Anatomy, *New York University Dental College, 209 East Twenty-third St., New York City.*

HOWDEN, ROBERT, M.A., M.B., C.M., D.Sc., L.L.D., Professor of Anatomy and Registrar, University of Durham, *14 Burdon Terrace, Newcastle-upon-Tyne, England.*

HOWELL, A. BRAZIER, A.B., Scientific Assistant, Division of Biological Investigations, *U. S. National Museum, Washington, D. C.*

HOWLAND, RUTH B., Ph.D., Assistant Professor of Biology, Washington Square College, *New York University, 32 Waverly Place, New York City.*

HOY, WM. E., JR., A.B., Ph.D., Professor of Biology, *Presbyterian College of South Carolina, Clinton, S. C.*

HRDLIČKA, ALEŠ, Ph.D., M.D., Curator, Division of Physical Anthropology, *United States National Museum, Washington, D. C.*

HUBER, ERNST, Ph.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HUBER, G. CARL, M.D. (Second Vice-Pres. '00–'01, Secretary-Treasurer '02–'14, Pres. '14–'16, Ex. Com. '20–'23), Professor of Anatomy and Director of the Anatomical Laboratories, University of Michigan, *1330 Hill St., Ann Arbor, Mich.*

HUGHSON, WALTER, S.B., M.D., Associate Professor of Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

HUMPHREY, RUFUS R., A.B., A.M., Ph.D., Associate Professor of Anatomy, School of Medicine, University of Buffalo, *24 High St., Buffalo, N. Y.*

HUNTER, OSCAR B., A.B., A.M., M.D., Assistant Dean and Professor of Pathology and Bacteriology, *George Washington Medical School, 1335 H. St., N.W., Washington, D. C.*

INGALLS, N. WILLIAM, B.S., M.D., Associate Professor of Anatomy, School of Medicine, Western Reserve University, *2109 Adelbert Road, Cleveland, Ohio.*

INGVAR, SVEN, M.D., Docent in Neurology, *University of Lund, Lund, Sweden.*

JACKSON, CLARENCE M., M.S., M.D. (Ex. Com. '10–'14, '23–, Vice-Pres. '16–'17, Pres. '22–'23), Professor and Director of the Department of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

JENKINS, GEORGE B., M.D., Professor of Anatomy, *George Washington University Medical School, Washington, D. C.*

JOB, THESLE T., A.B., M.S., Ph.D., Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*

JOHNSON, CHARLES EUGENE, A.M., Ph.D., Professor of Forest Zoölogy and Acting Director of the Roosevelt Wild Life Forest Experiment Station, *Department of Forest Zoölogy, State College of Forestry, Syracuse, N. Y.*

JOHNSON, FRANKLIN P., A.M., Ph.D., M.D., Urologist, *Suite 501, Park Building, Portland, Ore.*

JOHNSON, SYDNEY E., Ph.D., M.D., Professor of Gross Anatomy, School of Medicine, University of Louisville, *101 West Chestnut St., Louisville, Ky.*

JOHNSTON, JOHN B., Ph.D., Professor of Comparative Neurology, *University of Minnesota, Minneapolis, Minn.*

JOHNSTON, THOMAS BAILLIE, M.B., Ch.B., Professor of Anatomy, University of London, *Guy's Hospital Medical School, London, S. E. 1, England.*

JOHNSTONE, PAUL N., A.B., M.D., *Henry Ford Hospital, Detroit, Mich.*

JORDAN, HARVEY ERNEST, A.M., Ph.D. (Ex. Com. '18–'21), Professor of Histology and Embryology, *Department of Medicine, University of Virginia, Charlottesville, Va.*

KAAN, HELEN WARTON, Ph.D., Instructor in Anatomy, *New York University and Bellevue University Medical School, New York City.*

KAMPMEIER, OTTO FREDERICK, A.B., Ph.D., M.D., Associate Professor of Anatomy, *College of Medicine, University of Illinois, Chicago, Ill.*

KAPPERS, CORNELIUS URBO ARIËNS, M.D., Director of the Central Institute for Brain Research of Holland, *Mauritskade 61, Amsterdam, Holland.*

KEEGAN, JOHN J., A.M., M.D., Dean, *University of Nebraska, College of Medicine, Omaha, Neb.*

KEILLER, WILLIAM, L.R.C.P. and F.R.C.S. Ed. (Second Vice-Pres. '98–'99), Professor of Anatomy, Medical Department, University of Texas, *State Medical College, Galveston, Texas.*

KEITH, ARTHUR, M.D., LL.D., F.R.C.S., F.R.S., Hunterian Professor of Anatomy, *Royal College of Surgeons, Lincoln's Inn Fields, London, W. C. 2, England.*

KERNAN, JOHN D., JR., A.B., M.D., *120 East Seventy-fifth St., New York City.*

KERR, ABRAM T., B.S., M.D., (Ex. Com. '10–'14), Professor of Anatomy and Secretary of Cornell University Medical School, *Cornell University Medical College, Ithaca, N. Y.*

KEY, J. ALBERT, B.S., M.D., Director of Research, *Shriner's Hospital for Crippled Children, St. Louis, Mo.*

KINDRED, JAMES ERNEST, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, University of Virginia, *R.F.D. No. 4, Charlottesville, Va.*

KING, HELEN DEAN, A.M., Ph.D., Assistant Professor of Embryology, *The Wistar Institute of Anatomy, 36th St. and Woodland Ave., Philadelphia, Pa.*

KINGERY, HUGH MCMILLAN, A.B., A.M., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Colorado, Denver, Col.*

KINGSBURY, BENJAMIN F., A.B., Ph.D., M.D. (Ex. Com. '22–'25), Professor of Histology and Embryology, Cornell University, *2 South Ave., Ithaca, N. Y.*

KINGSLEY, JOHN STERLING, Sc.D., Professor Emeritus of Zoölogy, University of Illinois, *2500 Cedar Ave., Berkeley, Calif.*

KIRKHAM, WILLIAM BARRI, Ph.D., Professor of Biology, Springfield College, *100 Mill St., Springfield, Mass.*

KNOWER, HENRY MCE., A.B., Ph.D., (Ex. Com. '11–'15, '24–'26), Professor of Anatomy, Head of Department, *University of Alabama, Tuscaloosa, Alabama.*

KOCH, JOHN C., B.S., M.D., Junior Physician, Harper Hospital, *265 Euclid Ave., East, Detroit, Mich.*

Kofoid, Charles Atwood, A.B., Ph.D., Sc.D., Professor of Zoölogy, University of California, *Department of Zoölogy, University of California, Berkeley, Calif.*

Kornhauser, S. I., M.A., Ph.D., Professor of Anatomy, *University of Louisville, Medical School, Louisville, Ky.*

Krause, Allen Kramer, A.B., A.M., M.D., Associate Professor of Medicine, Director of Kenneth Dows Tuberculosis Research Laboratories, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

Kudo, Tokuyasu, M.D., Professor of Anatomy and Histology, *Niigata Medical College, Niigata City, Echigo, Japan.*

Kunitomo, Kanae, M.D., Professor of Anatomy, *Anatomical Institute, Nagasaki Medical School, Nagasaki, Japan.*

Kunkel, Beverly Waugh, Ph.B., Ph.D., Professor of Biology, *Lafayette College, Easton, Pa.*

Kuntz, Albert, Ph.D., M.D., Professor of Anatomy and Biology, *St. Louis University Medical School, 1402 South Grand Ave., St. Louis, Mo.*

Kutchin, Mrs. Harriet Lehmann, A.M., *"The Maplewood," Green Lake, Wis.*

Lambert, Adrian V. S., A.B., M.D., Associate Professor of Surgery, *Columbia University, 168 East Seventy-first St., New York City.*

Lambert, Avery Eldorus, B.S., Ph.D., Professor of Anatomy, Department of Anatomy, *University of Iowa, Iowa City, Iowa.*

Landacre, Francis Leroy, Ph.D., Professor of Anatomy and Head of Department, Ohio State University, *2026 Inka Ave., Columbus, Ohio.*

Langworthy, Orthello R., A.B., A.M., M.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Larsell, Olof, A.M., Ph.D., Professor of Anatomy, *University of Oregon Medical School, Portland, Oregon.*

Latimer, Homer B., A.M., Ph.D., Professor of Anatomy, *Medical School, University of Kansas, Lawrence, Kansas.*

Latta, John S., A.B., Ph.D., Associate Professor of Anatomy, University of Nebraska, College of Medicine, *Forty-second and Dewey Ave., Omaha, Neb.*

Lee, Ferdinand Christian, A.B., M.D., Associate in Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

Lee, Thomas G., B.S., M.D. (Ex. Com. '08–'10, Vice-Pres. '12–'14), Professor of Comparative Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

Leidy, Joseph, Jr., A.B., A.M., M.D., *1713 Walnut St., Philadelphia, Pa.*

Levi, Giuseppe, M.D., Professor of Anatomy, *University of Torino, Istituto anatomico, Corso d'Azeglio 52, Torino, Italy.*

Lewis, Dean D., M.D., Professor of Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

Lewis, Frederic T., A.M., Sc.D., LL.D. M.D. (Ex. Com. '09–'13, Vice-Pres. '14–'16), Associate Professor of Embryology, *Harvard Medical School, Boston, Mass.*

Lewis, Margaret Reed, M.A., Collaborator, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

Lewis, Warren Harmon, B.S., M.D. (Ex. Com. '09–'11, '14–'17), Research Associate, Department of Embryology, Carnegie Institution, Professor of Physiological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

LILLIE, FRANK RATTRAY, Ph.D., Sc.D., Professor of Embryology, Chairman of Department of Zoölogy, University of Chicago; Director Marine Biological Laboratory, Woods Hole, Mass., *University of Chicago, Chicago, Ill.*

LINEBACK, PAUL EUGENE, A.B., M.D., Professor of Microscopic Anatomy, *Atlanta Medical College, Emory University, Ga.*

LINELL, ERIC AMBROSE, Ch.B., M.D., Assistant Professor of Anatomy, *University of Toronto, Toronto, Canada.*

LIPSCHUTZ, BENJAMIN, M.D., Instructor in Neuro-anatomy, Jefferson Medical College, *1007 Spruce St., Philadelphia, Pa.*

LOEB, HANAU WOLF, A.M., M.D., Dean and Professor of the Diseases of the Ear, Nose and Throat, St. Louis University, *1402 South Grand Boulevard, St. Louis, Mo.*

LORD, FREDERIC P., A.B., M.D., Professor of Anatomy, *Dartmouth Medical School, 39 College St., Hanover, N. H.*

LOTH, EDWARD, M.D., Ph.D., Professor of Anatomy, *University of Warsaw, Warsaw, Poland.*

LOWREY, LAWSON GENTRY, A.M., M.D., Psychiatrist in charge, Clinic for Child Guidance, National Committee for Mental Hygiene, *13507 Clifton Boulevard, Cleveland, Ohio.*

MCCLUNG, CLARENCE E., Ph.G., A.B., A.M., Ph.D., Professor of Zoölogy and Director of the Zoölogical Laboratory, *University of Pennsylvania, Philadelphia, Pa.*

MCCLURE, CHARLES FREEMAN WILLIAMS, A.M., Sc.D. (Vice-Pres. '10–'11. Ex. Com. '12–'16, Pres. '20–'21), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

MCCOTTER, ROLLO E., M.D., Professor of Anatomy, Medical Department, University of Michigan, *1043 Ferdon Road, Ann Arbor, Mich.*

MCFARLAND, FRANK MACE, A.M., Ph.D., Professor of Histology, Leland Stanford Junior University, *2 Cabrillo Avenue, Stanford University, Calif.*

MCGILL, CAROLINE, A.B., A.M., Ph.D., M.D., Physician, *58 W. Quartz, Butte, Mont.*

MCKIBBEN, PAUL S., Ph.D., F.R.S.C., Professor of Anatomy, *University of Western Ontario Medical School, London, Canada.*

MCMURRICH, JAMES PLAYFAIR, A.M., Ph.D., LL.D. (Ex. Com. '06–'07, '17–'20, Pres. '08–'09), Professor of Anatomy, *University of Toronto, Toronto, Canada.*

MCNUTT, G. W., D.V.M., Instructor in Veterinary Anatomy, *Division of Veterinary Medicine, Iowa State College, Ames, Iowa.*

MACKLIN, C. C., M.B., M.D., M.A., Ph.D., F.R.S.C., Professor of Histology and Embryology, *University of Western Ontario Medical School, London, Ontario, Canada.*

MAGATH, THOMAS BYRD, M.S., Ph.D., M.D., Associate in Clinical Laboratories, University of Minnesota, *Mayo Clinic, Rochester, Minn.*

MALONE, EDWARD F., A.B., M.D., Professor of Histology, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*

MANGUM, CHARLES S., A.B., M.D., Professor of Anatomy, *University of North Carolina, 409 East Franklin St., Chapel Hill, N. C.*

MARK, EDWARD LAURENS, Ph.D., LL.D., Hersey Professor of Anatomy (emeritus) and Director of the Bermuda Biological Station for Research, Harvard University, *109 Irving St., Cambridge, Mass.*

MASON, KARL E., Ph.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

MASTIN, EDWARD V., M.S., M.D., Surgeon, *1043 Missouri Theatre Building, St. Louis, Mo.*

MATAS, RUDOLPH, M.D., LL.D., Professor of Surgery and Demonstrator of Anatomy, Tulane University of Louisiana, *2255 St. Charles Ave., New Orleans, La.*

MATTINGLY, MARIE DEES, M.D., Assistant Professor of Anatomy, *Tulane University of Louisiana, New Orleans, La.*

MAVOR, JAMES WATT, B.A., M.A., Ph.D., Professor of Biology, *Union College, Schenectady, N. Y.*

MAXIMOW, ALEXANDER, M.D., Professor of Anatomy, *Department of Anatomy, University of Chicago, Chicago, Ill.*

MEAD, HAROLD TUPPER, B.A., M.S., Associate Professor of Zoölogy, *Tulane University, New Orleans, La.*

MEAKER, SAMUEL R., A.B., M.D., M.R.C.S. (Eng.), Associate Professor of Gynaecology, Boston University School of Medicine, *240 Longwood St., Boston, Mass.*

MERCER, WILLIAM F., Ph.B., Ph.M., Ph.D., Professor of Biology, Ohio University, *Box 384, Athens, Ohio.*

MEYER, ADOLF, M.D., LL.D., Professor of Psychiatry and Director of the Phipps Psychiatric Clinic, *Johns Hopkins Hospital, Baltimore, Md.*

MEYER, ARTHUR W., S.B., M.D. (Ex. Com. '12–'16, Vice-Pres. '24–'25), Professor of Anatomy, Leland Stanford Junior University, *121 Waverly St., Palo Alto, Calif.*

MICHELS, NICHOLAS A., M.A., Dr.Sc., Assistant Professor of Biology, *St. Louis University School of Medicine, St. Louis, Mo.*

MILLER, ADAM M., A.M., Dean and Professor of Anatomy, Long Island College Hospital, *335 Henry St., Brooklyn, N. Y.*

MILLER, SHIRLEY P., A.B., A.M., Instructor in Anatomy, *Anatomical Institute, University of Minnesota, Minneapolis, Minn.*

MILLER, WILLIAM SNOW, M.D., Sc.D. (Vice-Pres. '08–'09), Professor of Anatomy (Emeritus), University of Wisconsin, *2001 Jefferson St., Madison, Wis.*

MOODIE, ROY L., A.B., Ph.D., Associate Professor of Anatomy, *University of Illinois, Medical College, Congress and Honore Sts., Chicago, Ill.*

MOODY, ROBERT ORTON, B.S., M.D., Associate Professor of Anatomy, University of California, *2826 Garber St., Berkeley, Calif.*

MORGAN, LAWRENCE ONIS, A.B., A.M., Ph.D., Instructor in Anatomy, University of Illinois, College of Medicine, *1819 West Polk St., Chicago, Ill.*

MORRILL, CHARLES V., A.M., Ph.D., Associate Professor of Anatomy, *Cornell University Medical School, First Ave. and Twenty-eighth St., New York City.*

MORTON, DUDLEY JOY, M.D., Assistant Professor, Department of Surgery, Yale University School of Medicine, and Research Associate, American Museum of Natural History, New York City, *169 Cold Spring St., New Haven, Conn.*

MOSSMAN, HARLAND W., Ph.D., Instructor in Anatomy, *University of Wisconsin, Madison, Wis.*

MULL, PHILIP L., B.S., M.D., Professor of Anatomy, *University of Mississippi Medical School, Box 102, University, Miss.*

MUNSON, JOHN P., M.S., Ph.D., F.R.S.A., Head of the Department of Biology, Washington State Normal School, *706 North Anderson St., Ellensburg, Washington.*

MURRAY, H. A., JR., A.B., A.M., M.D., Research Fellow, *Harvard University, Cambridge, Mass.*

MYERS, BURTON D., A.M., M.D., Professor of Anatomy and Assistant Dean of the Indiana University School of Medicine, *424 N. Walnut St., Bloomington, Ind.*

MYERS, JAY A., M.S., Ph.D., M.D., Assistant Professor of Preventive Medicine, *University of Minnesota Medical School, Minneapolis, Minn.*

MYERS, MAE LICHTENWALNER, M.D., Professor of Histology and Embryology, *Women's Medical College of Pennsylvania, 34 West Pomona St., Germantown, Philadelphia, Pa.*

NACHTRIEB, HENRY FRANCIS, B.S., Professor Emeritus, Animal Biology, University of Minnesota, *2448 Cedar St., Berkeley, Calif.*

NADGIR, Y. G., M.D., Professor of Anatomy, *Grant Medical College, Bombay, India.*

NANAGAS, JUAN CANCIO, M.D., Associate Professor of Anatomy, *College of Medicine and Surgery, 719 Florida Ave., Manila, Philippine Islands.*

NEAL, HERBERT VINCENT, A.M., Ph.D., Professor of Zoölogy, Tufts College, *Tufts College, 57, Mass.*

NICHOLAS, JOHN SPANGLER, M.S., Ph.D., Assistant Professor of Anatomy, *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

NOBACK, GUSTAVE J., B.S., M.A., Ph.D., Associate Professor of Anatomy, New York University and Bellevue Medical College, *338 East Twenty-sixth St., New York City.*

NOBLE, GLADWIN K., A.B., M.A., Ph.D., Curator of Herpetology, *American Museum of Natural History, New York City.*

NONIDEZ, JOSÉ F., Sc.M., Sc.D., Associate in Anatomy, Cornell University Medical College, *477 First Ave., New York City.*

NORRIS, H. W., A.B., Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*

OBENCHAIN, JEANETTE B., Ph.D., Research Associate, Department of Anatomy, *University of Chicago, Chicago, Ill.*

O'DONOGHUE, CHARLES H., D.Sc., F.Z.S., Professor of Zoölogy, *University of Manitoba, Winnipeg, Canada.*

OKAJIMA, K., M.D., Professor of Anatomy, *Keio University Medical College, Yotsuya, Tokio, Japan.*

OSTERUD, HJALMAR L., A.B., A.M., Ph.D., Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*

PAINTER, THEOPHILUS S., Ph.D., Adjunct Professor of Zoölogy, *School of Zoölogy, University of Texas, Austin, Texas.*

PAPANICOLAOU, GEORGE N., Ph.D., M.D., Assistant Professor of Anatomy, *Cornell University Medical College, Twenty-eighth St. and First Ave., New York City.*

PAPEZ, JAMES WENCESLAS, B.A., M.D., Assistant Professor of Anatomy and Neurology, *Cornell University Medical College, Ithaca, N. Y.*

PARKER, GEORGE HOWARD, D.Sc., Professor of Zoölogy and Director of Zoölogical Laboratory, *Harvard University, 16 Berkeley St., Cambridge, Mass.*

PATON, STEWART, A.B., M.D., Lecturer in Neurobiology, *Princeton University, Princeton, N. J.*

PATTEN, BRADLEY MERRILL, A.M., Ph.D., Associate Professor of Histology and Embryology, School of Medicine, Western Reserve University, *2109 Adelbert Road, Cleveland, Ohio.*

PATTEN, WILLIAM, Ph.D., Professor of Zoölogy, *Dartmouth College, Hanover, N. H.*

PATTERSON, JOHN THOMAS, B.S., Ph.D., Professor and Chairman of the Department of Zoölogy, University of Texas, *1908 Cliff St., Austin, Texas.*

PERKINS, ORMAN C., A.B., A.M., M.D., Professor of Neurology, Long Island College Hospital, *1279 East Nineteenth St., Brooklyn, N. Y.*

PIERSOL, WILLIAM HUNTER, A.B., M.B., Professor of Histology and Embryology, University of Toronto, *35 Dunvegan Road, Toronto, Canada.*

POHLMAN, AUGUSTUS G., M.D., Professor of Anatomy, St. Louis University, School of Medicine, *1402 South Grand Ave., St. Louis, Mo.*

POLJAK, STEPHEN, M.D., Docent in Neurology, Zagreb University, Jugo-Slavia, *Department of Anatomy, University of Chicago, Chicago, Ill.*

POTTER, PETER, M.S., M.D., Oculist and Aurist, Murray Hospital, Butte, Montana, *125 W. Granite St., Butte, Montana.*

POYNTER, CHARLES W. M., B.S., M.D. (Ex. Com. '19–'22), Professor of Anatomy, College of Medicine, University of Nebraska, *Forty-second and Dewey Ave., Omaha, Neb.*

PRENTISS, H. J., M.D., M.E., Professor of Anatomy, Embryology, and Histology, *State University of Iowa, Iowa City, Iowa.*

PRYOR, JOSEPH WILLIAM, M.D., Professor of Anatomy and Physiology, *University of Kentucky, 408 West Third St., Lexington, Ky.*

RADASCH, HENRY E., M.S., M.D., Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, Eleventh and Clinton Sts., Philadelphia, Pa.*

RANSON, STEPHEN W., M.D., Ph.D. (Ex. Com. '21–'24, Vice-Pres. '26–), Professor of Neuro-Anatomy, *Washington University Medical School, St. Louis, Mo.*

RASMUSSEN, ANDREW T., Ph.D., Professor of Neurology, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

REAGAN, FRANKLIN P., Ph.D., Assistant Professor of Zoölogy, *Department of Zoölogy, University of California, Berkeley, Calif.*

REED, HUGH D., B.S., Ph.D., Professor of Zoölogy, Cornell University, *McGraw Hall, Ithaca, N. Y.*

REINKE, EDWIN E., M.A., Ph.D., Professor of Biology, *Vanderbilt University, Nashville, Tenn.*

DE RÉNYI, GEORGE ST., M.D., Assistant Professor of Anatomy, *School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

REVELL, DANIEL GRAISBERRY, A.B., M.B., Professor of Anatomy, University of Alberta, *Edmonton, South, Strathcona P. O., Alberta, Canada.*

RHINEHART, D. A., A.M., M.B., Professor of Applied Anatomy, University of Arkansas, *1624 West Twenty-first St., Little Rock, Ark.*

RICE, EDWARD LORANUS, A.B., Ph.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware. Ohio.*

RIENHOFF, WILLIAM F., JR., A.B., M.D., Instructor in Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

RINGOEN, ADOLPH R., A.M., Ph.D., Assistant Professor of Zoölogy, University of Minnesota, *1469 Grantham St., St. Paul, Minn.*

ROBERTSON, ALBERT DUNCAN, B.A., Professor of Zoölogy, *Western University, London, Ontario, Canada.*

ROBINSON, ARTHUR, M.D., F.R.C.S. (Edinburgh), Professor of Anatomy, University of Edinburgh, *University, Teviot Place, Edinburgh, Scotland.*

ROBINSON, BYRON L., B.A., M.B., M.A., Professor of Microscopic Anatomy, *University of Arkansas Medical School, Little Rock, Ark.*

ROGERS, WILLIAM MITCHELL, B.S., Instructor in Histology and Embryology, *Cornell University, Ithaca, N. Y.*

ROMER, ALFRED S., B.A., Ph.D., Associate Professor of Vertebrate Palaeontology, *Walker Museum, University of Chicago, Chicago, Ill.*

RUPERT, R. R., M.D., *1225 Washington St., Oakland, Calif.*

RUTH, EDWARD S., M.D., Associate Surgeon, Children's Hospital, *6548½ Hollywood Bldg., Hollywood, Calif.*

SABIN, FLORENCE R., B.S., M.D., Sc.D. (Second Vice-Pres. '08–'09, Pres. '24–'25), Member of Rockefeller Institute, *Rockefeller Institute for Medical Research. Sixty-sixth St. and Avenue A, New York City.*

SACHS, ERNEST, A.B., M.D., Professor of Clinical and Neurological Surgery, Washington University School of Medicine, Associate Surgeon to Barnes and St. Louis Children's Hospitals, Associate Surgeon in charge Neurological Surgery, Jewish Hospital, *97 Arundel Place, St. Louis, Mo.*

SANSOM, GEORGE SAMUEL, B.S., M.C., D.F.C., Honorary Research Assistant, *Institute of Anatomy, University College, London, W.C.1, England.*

SANTEE, HARRIS E., A.M., Ph.D., M.D., *R. F. D., Box 72, West Chicago, Ill.*

SCAMMON, RICHARD E., Ph.D. (Ex. Com. '23–26), Professor of Anatomy, *Institute of Anatomy, University of Minnesota, 33 Arthur Ave., S. E., Minneapolis, Minn.*

SCHAEFER, MARIE CHARLOTTE, M.D., Professor of Histology and Embryology, Medical Department, University of Texas, *2202 Avenue M, Galveston, Texas.*

SCHAEFFER, JACOB PARSONS, A.M., M.D., Ph.D. (Ex. Com. '24–), Professor of Anatomy and Director of the Daniel Baugh Institute of Anatomy, *4634 Spruce St., Philadelphia, Pa.*

SCHOCHET, SYDNEY S., M.D., *4716 Ellis Ave., Chicago, Ill.*

SCHOEMAKER, DANIEL M., B.S., M.D., Professor of Anatomy, Medical Department, St. Louis University, *1402 South Grand Ave., St. Louis, Mo.*

SCHULTE, HERMANN VON W., A.B., M.D. (Ex. Com. '15–'18), Professor of Anatomy and Dean, *Creighton Medical College, Omaha, Neb.*

SCHULTZ, ADOLPH H., Ph.D., Associate Professor of Physical Anthropology, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

SCOTT, GORDON H., Ph.D., Assistant Professor of Anatomy, Loyola University School of Medicine, *706 South Lincoln St., Chicago, Ill.*

SCOTT, JOHN W., A.B., Ph.D., Professor of Zoölogy and Research Parasitologist, *University of Wyoming, Laramie, Wyoming.*

SCOTT, J. TERRELL, A.B., A.M., M.D., Instructor in Anatomy, *University of Colorado Medical School, Denver, Colo.*

SELLING, LAWRENCE, A.B., M.D., Clinician in Medicine, University of Oregon Medical School, *Mayer Building, Portland, Ore.*

SENIOR, H. D., M.D., D.Sc., F.R.C.S. (Vice-Pres. '22–'23), Professor of Anatomy, New York University and Bellevue Hospital Medical College, *338 East Twenty-sixth St., New York City.*

SHANER, RALPH FAUST, Ph.D., Associate Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

SHARP, CLAYTON, A.B., M.D., Associate Professor of Anatomy and Histology, Columbia University, *437 West Fifty-ninth St., New York City.*

SHELLSHEAR, JOSEPH LEXDEN, M.B., Ch.M., Professor of Anatomy, *University of Hongkong, Hongkong, China.*

SHIELDS, RANDOLPH TUCKER, A.B., M.D., Professor of Histology and Embryology, School of Medicine, *Shantung Christian University, Tsinan, Shantung, China.*

SHIMIDZU, YOSHITAKA, M.D., Professor of Gynecology, *Nagasaki Medical College, Nagasaki, Japan.*

SIMKINS, CLEVELAND S., A.B., Ph.D., Associate Professor of Anatomy, Histology, and Embryology, University of Tennessee Medical School, *875 Monroe Ave., Memphis, Tenn.*

SIMPSON, MIRIAM ELIZABETH, A.B., M.S., Ph.D., M.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*

SLUDER, GREENFIELD, M.D., Clinical Professor of Laryngology and Rhinology, Washington University Medical School, *3542 Washington Ave., St. Louis, Mo.*

SMITH, BERTRAM GARNER, A.B., Ph.D., Associate Professor of Anatomy, New York University Medical College, *338 East Twenty-sixth St., New York City.*

SMITH, CHRISTIANNA, A.M., Assistant Professor, *Mount Holyoke College, South Hadley, Mass.*

SMITH, DAVID T., A.B., M.D., Bacteriologist, New York State Hospital for Incipient Tuberculosis, *Ray Brook, N. Y.*

SMITH, GEORGE MILTON, A.B., M.D., Attending Surgeon, Waterbury Hospital, *111 Buckingham St., Waterbury, Conn.*

SMITH, GRAFTON ELLIOT, M.A., M.D., F.R.S., Ch.M., L.D., F.R.C.P., Professor of Anatomy, *University College, Gower St., London, W. C. 1, England.*

SMITH, H. P., A.B., M.S., M.D., Assistant Professor of Pathology, *University of Rochester School of Medicine and Dentistry, Elmwood Ave., Rochester, N. Y.*

SMITH, PHILIP EDWARD, M.S., Ph.D., Associate Professor of Anatomy, *Leland Stanford University, Palo Alto, Calif.*

SMITH, WILBUR CLELAND, M.D., Professor of Gross Anatomy, *Tulane University, New Orleans, La.*

SNOW, PERRY G., A.B., M.D., Professor of Anatomy, *University of Utah Medical School, Salt Lake City, Utah.*

SNYDER, FRANKLIN FAUST, M.D., Assistant Professor of Anatomy, *University of Rochester Medical School, Rochester, N. Y.*

SPAULDING, M. H., A.B., A.M., Professor of Zoölogy, University of Montana, *507 South Eighth Ave., Bozeman, Montana.*

SPEIDEL, CARL C., Ph.B., Ph.D., Associate Professor of Anatomy, University of Virginia, *University, Va.*

STALEY, FOREST H., A.B., M.D., Instructor in Surgery, *St. Louis University School of Medicine, St. Louis, Mo.*

STARK, MARY, Ph.B., M.A., Ph.D., Professor of Histology and Embryology, *New York Homeopathic College, Sixty-fourth St. and Avenue A, New York City.*

STEVENSON, PAUL H., B.S., M.D., Associate in Anatomy, *Peking Union Medical College, Peking, China.*

STEWART, FRED WALDORF, A.B., Ph.D., M.D., Division of Pathology and Bacteriology, *The Rockefeller Institute for Medical Research, New York City.*

STILES, HENRY WILSON, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *309 Orange St., Syracuse, N. Y.*

STOCKARD, CHARLES RUPERT, M.D.,M.S., Ph.D., Sc.D. (Secretary-Treasurer '14–'21, Ex. Com. '23–), Professor of Anatomy, *Cornell University Medical College, New York City.*

STONE, LEON STANSFIELD, Ph.B., Ph.D., Assistant Professor of Anatomy, *Sterling Hall of Medicine, Anatomy Department, Cedar St., New Haven, Conn.*

STONE, ROBERT S., B.A., M.A., M.B., *1429 David Whitney Building, Detroit, Mich.*

STOPFORD, JOHN SEBASTIAN B., M.D., Professor of Anatomy, *University of Manchester, Manchester, England.*

STRAUS, WILLIAM L., JR., Ph.D., National Research Fellow in Anatomy, *Western Reserve University, School of Medicine, Cleveland, Ohio.*

STREETER, GEORGE L., A.M., M.D. (Ex. Com. '18–'20, Pres. '26–), Director, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

STROMSTEN, FRANK ALBERT, D.Sc., Associate Professor of Animal Biology, State University of Iowa, *207 Natural Science Building, Iowa City, Iowa.*

STRONG, LEON H., Ph.D., Assistant Professor of Anatomy, *Indiana University School of Medicine, Bloomington, Ind.*

STRONG, OLIVER S., A.B., A.M., Ph.D., Associate Professor of Neurology, Columbia University, *437 West Fifty-ninth St., New York City.*

STRONG, REUBEN MYRON, A.B., A.M., Ph.D. (Ex. Com. '16–'19), Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*

SULLIVAN, WALTER EDWARD, A.M., Ph.D., Professor of Anatomy, University of Wisconsin, *Science Hall, Madison, Wis.*

SUNDWALL, JOHN, Ph.D., M.D., Professor of Hygiene, Director of Student and Physical Welfare, University of Michigan, *619 East University Ave., Ann Arbor, Mich.*

SUTTON, ALAN CALLENDER, A.B., M.D., Instructor in Clinical Medicine, Johns Hopkins University, *5600 Pimlico Road, Baltimore, Md.*

SWETT, FRANCIS HUNTINGTON, A.M., Ph.D., Associate Professor of Anatomy, *Vanderbilt Medical School, Nashville, Tenn.*

SWIFT, CHARLES H., M.D., Ph.D., Assistant Professor of Anatomy, *Department of Anatomy, University of Chicago, Chicago, Ill.*

SWINGLE, W. W., A.B., A.M., Ph.D., Professor of Zoölogy, State University of Iowa, *Zoölogical Laboratory, University of Iowa, Iowa City, Iowa.*

SYKES, GEO. F., Ph.B., M.A., Assistant Professor of Anatomy, *Tufts College Medical School, Boston, Mass.*

TAKENOUCHI, MATSUZIRO, M.D., Assistant Professor of Bacteriology and Hygiene, *Medical College, Imperial University of Tokio, Tokio, Japan.*

TERRY, ROBERT JAMES, A.B., M.D. (Ex. Com. '08–'12, '21–'24), Professor of Anatomy, *Washington University Medical School, St. Louis, Mo.*

THOMAS, NEWTON GEORGE, B.A., A.M., D.D.S., Professor of Histology and Assistant Dean, *37 N. Boquet St., Oakland Station, Pittsburgh, Pa.*

THOMSON, ARTHUR, M.A., M.B., LL.D., F.R.C.S., D.C.L., Professor of Anatomy, *University of Oxford, Department of Human Anatomy, Oxford, England.*

THORKELSON, JACOB, M.D., *20 West Granite St., Butte, Mont.*

THRO, WILLIAM C., B.S., A.M., M.D., Professor of Clinical Pathology, *Cornell University Medical College, Twenty-eighth St. and First Ave., New York City.*

THURINGER, JOSEPH M., M.D., Professor of Histology and Embryology, *University of Oklahoma, Norman, Okla.*

THYNG, FREDERICK WILBUR, Ph.D., Professor of Anatomy, *Tufts Medical College, 416 Huntington Ave., Boston, Mass.*

TILNEY, FREDERICK, A.B., M.D., Ph.D., Professor of Neuro-Anatomy, Columbia University, *870 Madison Ave., New York City.*

TODD, T. WINGATE, M.B., Ch.B. (Manc.), F.R.C.S. (Eng.), (Vice-Pres. '20–'21, Ex. Com., '24–), Professor of Anatomy, Medical Department, Western Reserve University, *2109 Adelbert Road, Cleveland, Ohio.*

TRACY, HENRY C., A.B., A.M., Ph.D., Professor of Anatomy, *University of Kansas, Lawrence, Kansas.*

TROTTER, MILDRED, A.B., M.D., Assistant Professor in Anatomy, *Washington University Medical College, St. Louis, Mo.*

TSAI, CHIAO, Ph.D., Professor of Comparative Psychology, *Fuh Tan University, Kiangwan, Shanghai, China.*

TUPPER, PAUL YOER, M.D., Emeritus Professor of Surgery, Washington University Medical School, *Wall Building, St. Louis, Mo.*

TURNER, CLARENCE L., M.A., Ph.D., Professor of Zoölogy, *Beloit College, Beloit, Wisconsin.*

UHLENHUTH, EDUARD, Ph.D., Associate Professor in Anatomy, *University of Maryland Medical School, Baltimore, Md.*

VAN DER HORST, C. J., Ph.D., *Zoologisch Laboratorium, Place Doklaan, Amsterdam, Holland.*

VAN WAGENEN, GERTRUDE, A.B., Ph.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*

WAITE, FREDERICK CLAYTON, A.M., Ph.D., Professor of Histology and Embryology, Western Reserve University School of Medicine, *2109 Adelbert Road, Cleveland, Ohio.*

WALLIN, IVAN E., M.A., D.Sc., Professor of Anatomy and head of department, *University of Colorado, College of Medicine, Denver, Colo.*

WALMSLEY, THOMAS, M.D., F.R.S.E., Professor of Anatomy, *Queens University of Belfast, Belfast, Ireland.*

WARREN, JOHN, A.B., M.D. (Ex. Com. '23–'24), Associate Professor of Anatomy, *Harvard Medical School, Boston, Mass.*

WATERSTON, DAVID, M.A., M.D., F.R.C.S., Ed., Butte Professor of Anatomy, *University of St. Andrews, St. Andrews, Fife, Scotland.*

WATKINS, RICHARD WATKIN, B.S., M.D., *Presbyterian Hospital, Chicago, Ill.*

WATT, JAMES CRAWFORD, M.A., M.D., Associate Professor of Anatomy, University of Toronto, *20 Hawthorne Ave., Toronto, Canada.*

WEED, LEWIS HILL, A.B., A.M., M.D. (Ex. Com. '20–'21, Sec. Treas. '22–), Dean and Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

WHEELER, THEODORA, A.B., M.D., *604 Fifth St., S. W., Rochester, Minn.*

WHITESIDE, BEATRICE, B.A., Ph.D., Associate Professor of Histology, *Detroit College of Medicine and Surgery, Detroit, Mich.*

WHITNALL, S. E., M.A., M.D., B.Ch., Professor of Anatomy, *McGill University, Montreal, Canada.*

WIEMAN, H. L., Ph.D., Professor of Zoölogy, *University of Cincinnati, Cincinnati, Ohio.*

WILDER, HARRIS HAWTHORNE, Ph.D., Professor of Zoölogy, *Smith College, Northampton, Mass.*

WILLARD, WILLIAM A., A.M., Ph.D., Professor of Anatomy, University of Nebraska, *College of Medicine, Forty-second St. and Dewey Ave., Omaha, Neb.*

WILLIAMS, STEPHEN RIGGS, A.B., A.M., Ph.D., Professor of Zoölogy and Geology, Miami University, *300 East Church St., Oxford, Ohio.*

WILLIER, BENJAMIN HARRISON, Ph.D., Associate Professor of Zoölogy, *University of Chicago, Chicago, Ill.*

WILSON, JAMES THOMAS, M.A., M.B., F.R.S., Professor of Anatomy, *University of Cambridge, New Museums, Cambridge, England.*

WILSON, LOUIS BLANCHARD, M.D., Director of Pathology Division, Mayo Clinic and Mayo Foundation, Professor of Pathology in the University of Minnesota, *Mayo Clinic, 330 West College St., Rochester, Minn.*

WINDLE, WILLIAM F., B.S., M.S., Assistant Professor of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

WISLOCKI, GEORGE B., A.B., M.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

WITHERSPOON, THOMAS CASEY, M.D., *Murray Hospital, Butte, Mont.*

WITTENBORG, A. H., M.D., Professor of Anatomy, *College of Medicine, University of Tennessee, Memphis, Tenn.*

WOODMAN, ALICE S., M.D., Assistant Professor of Histology and Embryology, *Boston University School of Medicine, 80 East Concord St., Boston, Mass.*

WOOLLARD, HERBERT H., M.D., Demonstrator in Anatomy, *University College, Gower St., London, W. C. 1, England.*

WORCESTER, JOHN LOCKE, M.D., Professor of Anatomy, University of Washington, *5211 Twenty-first Ave., N. E., Seattle, Wash.*

DIFFERENCES IN THE GROWTH CURVES OF ALBINO RATS BORN DURING THE FOUR SEASONS OF THE YEAR UNDER UNIFORM LABORATORY CONDITIONS

FRANK BLAIR HANSON AND FLORENCE HEYS
Department of Zoölogy, Washington University

TWO FIGURES

INTRODUCTION

Seasonal differences in sex ratio, litter size, and birth weight of the albino rat under uniform laboratory conditions were dealt with in an earlier study (Hanson and Sholes, '24). The data based on 664 newborn young indicated clearly that in respect to sex ratio, litter size, and birth weight there are no significant differences between groups of rats born at different seasons under the conditions obtaining in this laboratory.

This present paper compares the growth in body weight for the first one hundred days of life of albino rats born during the four seasons of the year. The animals are divided into four groups—all those born in June, July, and August make one group; those of September, October and November, another; while December, January, and February, and March, April, and May constitute the winter and spring groups, respectively. Any such grouping of animals or division of the year is more or less an arbitrary one, and the objection to the method employed here is that those animals born near the end of one season have almost their entire growth period falling within the succeeding season. The data presented, then, are valid within the limitations imposed by these conditions.

TABLE 1

A table showing seasonal differences in growth of male and female albino rats born during the four seasons of the year when reared under uniform laboratory conditions

AGE IN DAYS		J–J–A	M–A–M	D–J–F	S–O–N
		Males			
20	M	25.00±0.67	24.14±0.28	24.93±0.48	24.42±0.36
	σ	6.57±0.47	4.19±0.20	6.34±0.34	5.17±0.25
	C	26.28±1.89	17.39±0.80	25.42±1.36	21.18±1.04
		(44)	(99)	(79)	(95)
40	M	61.19±1.59	66.12±1.08	64.86±1.34	69.21±1.10
	σ	15.30±1.13	15.87±0.76	17.03±0.94	15.37±0.78
	C	25.00±1.80	24.01±1.16	26.25±1.46	22.20±1.12
		(42)	(98)	(74)	(89)
60	M	99.00±3.50	112.86±2.16	116.84±2.03	119.02±1.83
	σ	32.80±2.47	31.69±1.53	26.27±1.49	24.62±1.30
	C	33.13±2.50	28.08±1.35	22.48±1.27	20.68±1.09
		(40)	(98)	(76)	(82)
80	M	148.21±4.63	157.97±2.81	158.88±2.97	160.77±2.39
	σ	36.36±3.28	40.36±1.99	34.95±2.10	31.10±1.69
	C	24.53±2.21	25.54±1.26	21.99±1.32	19.34±1.05
		(28)	(94)	(63)	(77)
100	M	196.11±7.63	205.00±4.69	193.14±3.58	206.81±3.16
	σ	47.97±5.39	42.90±3.32	37.91±2.53	38.07±2.23
	C	24.46±2.75	20.92±1.62	19.62±1.31	18.40±0.60
		(18)	(38)	(51)	(66)
		Females			
20	M	23.06±0.48	23.70±0.47	23.26±0.48	24.12±0.38
	σ	5.56±0.34	7.26±0.33	6.67±0.34	5.51±0.27
	C	24.11±1.46	30.63±1.41	28.66±1.45	22.86±1.11
		(62)	(108)	(89)	(97)
40	M	56.09±1.61	61.07±1.02	61.53±1.08	62.61±0.84
	σ	16.21±1.14	15.99±0.72	14.74±0.76	11.71±0.60
	C	28.90±2.03	26.18±1.18	23.95±1.81	18.70±0.95
		(46)	(112)	(85)	(88)
60	M	89.00±2.58	99.09±1.55	103.75±1.53	112.16±1.27
	σ	24.16±1.82	24.09±1.10	20.33±1.08	17.73±0.90
	C	27.15±2.05	24.31±1.11	19.59±1.04	15.80±0.80
		(40)	(110)	(80)	(88)
80	M	116.21±3.30	124.55±1.86	134.17±2.11	138.10±1.66
	σ	26.31±2.33	25.93±1.32	26.55±1.49	22.49±1.17
	C	22.64±2.01	20.82±1.06	19.78±1.11	16.28±0.85
		(29)	(88)	(72)	(84)
100	M	143.68±4.61	149.73±1.77	153.80±2.44	165.85±2.27
	σ	29.77±3.26	27.92±1.25	25.60±1.73	27.13±1.61
	C	20.71±2.27	18.64±0.84	16.64±1.12	16.35±0.97
		(19)	(113)	(50)	(65)

J–J–A, June–July–August; M–A–M, March–April–May; D–J–F, December–January–February; S–O–N, September–October–November. M, mean body weight in grams; σ, standard deviation; C, coefficient of variation. The numbers in parentheses indicate the number of rats upon which the three constants immediately above are based.

The physical environment of the animals in our colony was described in the paper by Hanson and Sholes ('24), from which the following paragraph is quoted:

The animals are kept in large comfortable cages, with a permanent water supply, and are fed with cooked food after a Wistar Institute

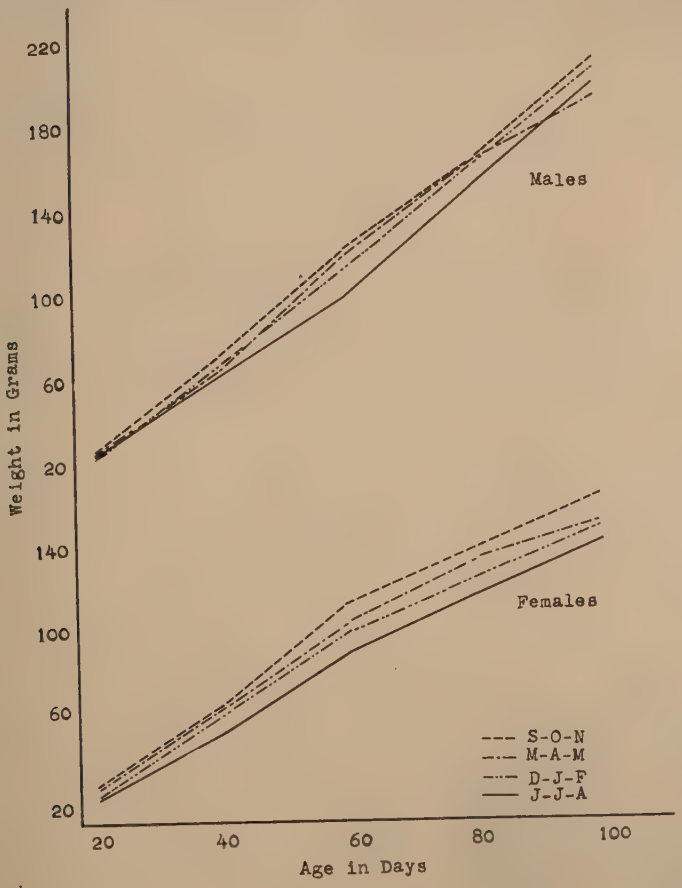


Fig. 1 Graphs based on data of table 1, showing comparative growth rates of four seasonal groups of male and female albino rats. *S-O-N*, *September*-October-November; *M-A-M*, March-April-May; *D-J-F*, December-January-February; *J-J-A*, June-July-August.

recipe. To this are added lettuce and dog biscuit. The diet seems to be a highly successful one judged by the condition of the animals and their breeding performance. The colony is housed in a basement room the floor of which is approximately level with the ground. Good light and ample ventilation are provided. The heating system for this room is separate from that of the rest of the building and can be controlled within reasonably narrow limits both day and night. With two stories of the building above the animal room the summer temperature is never excessive. . . .

TABLE 2

A table showing the highest seasonal weight minus the lowest seasonal weight for each age, together with the difference divided by the probable error

AGE IN DAYS	SEASON HIGHEST	SEASON LOWEST	DIFFERENCE	DIFF./P.E.
		Males		
20	J–J–A 25.00±0.67	M–A–M 24.14±0.28	0.86±0.73	1.05
40	S–O–N 69.21±1.10	J–J–A 61.19±1.59	8.02±1.93	4.15
60	S–O–N 119.02±1.83	J–J–A 99.00±3.50	20.02±3.95	5.07
80	S–O–N 160.77±2.39	J–J–A 148.21±4.63	12.56±5.21	2.41
100	S–O–N 206.81±3.16	D–J–F 193.13±3.58	13.68±4.79	2.85
		Females		
20	S–O–N 24.12±0.38	J–J–A 23.06±0.48	1.06±0.61	1.74
40	S–O–N 62.61±0.84	J–J–A 56.09±1.61	6.52±1.81	3.60
60	S–O–N 112.15±1.27	J–J–A 89.00±2.58	23.15±2.87	8.06
80	S–O–N 138.10±1.66	J–J–A 116.21±2.33	21.88±2.86	7.66
100	S–O–N 165.85±2.27	J–J–A 143.68±4.61	22.16±5.14	4.32

THE DATA

Table 1 gives mean body weight, standard deviation, and the coefficient of variation for males and females born during the four seasons of the year. Figure 1 visualizes the mean body weights at various ages, while figure 2 is the result of plotting the coefficients of variation against age in days.

Hanson and Sholes ('24) showed that birth weight is remarkably constant in albino rats, whether they happen to be born in summer or winter, spring or autumn. The difference between the means of the two most extreme groups (spring and autumn) was only 0.20 ± 0.10 grams. These differences are not much greater at twenty days of age. For

the males the mean difference in grams between the two extreme groups is only 0.86 ± 0.73; for the females it is 1.06 ± 0.61. None of these differences either for birth weight or at twenty days is statistically significant.

However, at all later ages for the females, and at forty and one hundred days for the males, the differences between the two most extreme of the four groups is significant. Table 2 gives these differences for males and females at the various ages. Females born in the fall months show the greatest

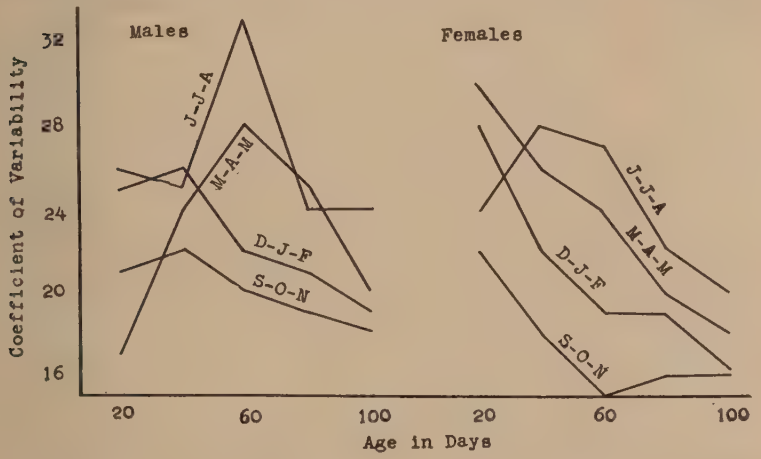


Fig. 2 Graphs based on data of table 2, showing percentage of variability as expressed by the coefficients of variation. Notice sharp decline of these constants with increasing age. Lettering same as in figure 1.

mean body weight at all ages and those born in the summer the lowest. This is also true of the males, with two exceptions.

Figure 2 indicates that there is considerable variability (coefficients of variation) in body weight among the four groups. Those animals born in the summer months show the highest percentage of variability and the lowest body weights; the fall group, the least variability and greatest mean body weights.

In both males and females for all seasonal groups, variability, as expressed by the coefficients of variability, decreases

with age. In the four seasonal groups of females this is especially striking. Just why there should be this consistent decrease in the coefficient of variation is not clear at the moment. Other workers have not reported similar results. King ('15) gives the means and coefficients of variation for two series of albino rats at monthly intervals for 485 days. The average value for the coefficient of variation in her results is for males 13.6 and for females 12.1. But the coefficients at all other ages are random departures above and below these values. There is nothing approaching the consistent decrease with age of the percentage of variability as expressed in figure 2.

Figure 1 gives some indication that the position of any seasonal group with relation to the other three is pretty largely determined by its relation to the other groups at twenty days of age. This is particularly true of the females. The high group (Sept.-Oct.-Nov.) is the highest at all ages, the low group (June-July-Aug.) is the lowest at all ages.

This opens the question as to what effect body weight at birth or at twenty days has upon subsequent growth. Is there any significant relation between early body weight and the weight of the full-grown animal?

This problem has been studied recently by Kopeć ('26) in rabbits. Using only litters ranging from four to nine young and eliminating oversized and undersized individuals, Kopeć found that newborn rabbits weighing from 43 to 60 grams maintain this advantage throughout life over young weighing from 31 to 42 grams at birth. There are contrary opinions to this in the literature and also confirmatory evidence, to which latter this data on seasonal growth differences contribute a small part.

CONCLUSION

A study is made of the growth capacity of albino rats born during the four seasons of the year. Birth weight is remarkably constant throughout the year, no significant difference being shown between groups born at different seasons. The same is true at twenty days of age.

From forty to one hundred days of age the four seasonal groups are growing at four different rates, and the differences between the two extreme groups are significant. Females born in the fall months show the greatest mean body weight at all ages, and those born in summer, the lowest.

The highest percentage of variability is associated with the summer group, which shows also the lowest mean body weight; the lowest percentage of variability with the fall group, which has the highest mean body weight at all ages.

Variability as measured by the coefficients of variation decreases sharply with age—an unexpected result and not evident in data of some other investigators.

Body weight at birth and up to twenty days seems to have a real influence upon the body weight of the adults—the heaviest group at twenty days being also the heaviest at one hundred days; the smallest at twenty days, the smallest at one hundred days.

LITERATURE CITED

HANSON, FRANK BLAIR, AND SHOLES, FAITH NICKELL 1924 Seasonal differences in sex ratio, litter size and birth weight of the albino rat under uniform laboratory conditions. Genetics, vol. 9, pp. 363–367.

KING, HELEN DEAN 1915 Growth and variability in the body weight of the albino rat. Anat. Rec., vol. 9, pp. 751–776.

KOPEĆ, STEFAN 1926 The morphogenetical value of the weight of rabbits at birth. Jour. Genetics, vol. 17, pp. 187–198.

MEDULLA INJURY IN RELATION TO CELLULAR PROLIFERATION IN AMBLYSTOMA EMBRYOS

S. R. DETWILER
Zoölogical Laboratory, Harvard University

ONE FIGURE

INTRODUCTION

In a paper dealing with the embryonic eye transplantations in Amblystoma (May and Detwiler, '25), we described a cellular hyperplasia in certain nerve centers which were penetrated by the growing optic nerve of the grafted eye. The experiment consisted in removing the otic vesicle and implanting an eye rudiment into the wound. In four cases the optic nerve of the grafted eye formed connections with the IX–X ganglionic complex. In three cases it connected with the unremoved portion of the VII–VIII ganglion, and in one case it entered the ventrolateral wall of the medulla. A study of the cases in which the nerve connected with the IX–X ganglion showed that this ganglion contained from 30 to 50 per cent more cells than the contralateral ganglionic mass and that it also shifted cephalad toward the entering optic nerve. In the case in which the grafted optic nerve entered the medulla, there was a shifting of the cells from the gray portion of the medulla into the white matter, so that there was a cellular connection between the gray area and the point of entrance of the nerve. A numerical comparison of the cells on the two sides of the medulla at the level of the entering nerve showed a cellular increase of 22 per cent on the side of operation.

Our results indicated a stimulating influence of the growing optic fibers upon the nerve centers which they penetrated.

In this connection we cited the experiments of Burr ('23, '24), who found a hyperplasia of 30 per cent in the olfactory portion of the hemisphere when augmentation of the olfactory fibers ensued as a result of experimental fusion of two nasal placodes. We also discussed our results in the light of other experiments suggesting a stimulating influence of growing fibers upon cellular development.

The question has arisen, in these and other experiments dealing with cellular hyperplasias in the nervous system, how far such cellular responses are due merely to injury inflicted during the grafting. In a recent paper (Detwiler, '25 c) this matter was discussed with specific reference to cellular increases found in various grafted segments of the spinal cord. Here it was brought out that cellular hyperplasias found in segments of the cord from the midtrunk region, when transplanted into the brachial region, must be looked upon as resulting from influences other than those brought about through injury. The present paper is concerned with the question of injury effects in the cellular hyperplasias following eye transplantations.

It is impossible to say to what extent the placode of the IX–X ganglion was disturbed in cases where such ganglia increased under the influence of the grafted eye. In the case where the optic nerve entered the medulla and where cellular disturbances were noted, the question arises as to how far such responses might be referable to possible injury on the medulla wall during the grafting. Excision of the ear vesicle and the implantation of an eye rudiment into the wound can readily be done without injury to the medulla wall, although there is always the possibility that in certain experiments some damage may be inflicted. For this reason, it seemed desirable to injure the medulla wall intentionally and note the effect.

EXPERIMENTAL

The experiments were carried out as follows: The ear vesicle and the adjacent tissue were excised, thus exposing

a considerable portion of the medulla wall to view. A hole was then cut in the wall, of sufficient size to permit readily the insertion of the cutting tips of iridectomy scissors into the ventricle. The wound was not covered over, so that temporarily there was connection of the medullary ventricle with the outside world. Twelve cases out of twenty survived. These were fixed at periods ranging from sixteen to forty-two days after the operation. Four cases fixed at sixteen,

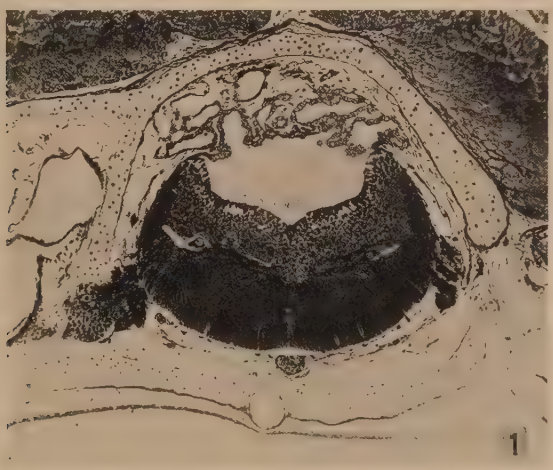


Fig. 1 Photomicrograph of transverse section of the medulla at the level of Mauthner's cell in case E. Ext. 2. The right ear was excised, and the adjacent medulla wall was considerably injured. Photo taken forty-two days after operation. × 58.

twenty-one, forty, and forty-two days, respectively, were sectioned and studied. The study was made with respect to the symmetry of the medulla at the level of injury, the comparative size of the contralateral walls and the number of cells present in a given number of sections at the level of the wound. In no case was there any deformity resulting from the injury. The external limiting membrane was completely intact, and there was no asymmetrical development (fig. 1). There was no evidence of cellular extensions through the

white matter, such as was found in the case when the grafted optic nerve pierced the medulla wall in former experiments.

Cell counts of the medulla were made in only four cases (table 1). For these counts ten consecutive transverse sections were selected at the level of Mauthner's cell, which represents a region at the level of the injury. The total number of cells on the side of injury was compared with that on the normal side. The ependymal cells were not counted. The results given in the table show that in an animal sixteen days after the injury considerably more cells were counted on the injured side than on the normal side, but in the three older cases (twenty-one days, forty days, and forty-two days) the numbers of cells on the two sides were practically equal.

TABLE 1

Showing number of cells counted in ten consecutive transverse sections of the medulla at the level of Mauthner's cell

CASE	AGE DAYS AFTER OPERATION	TOTAL NUMBER OF CELLS COUNTED		CELLULAR RATIO		PROBABLE ERROR	
		Injured side	Normal side	Injured side	Normal side	Injured side	Normal side
E. Ext. 9	16	5048	4102	1.23 :	1	4.8	6.7
E. Ext. 10	21	3499	3534	.99 :	1	5.6	5.3
E. Ext. 8	40	3452	3432	1 :	1	4.5	5.1
E. Ext. 2	42	3343	3252	1.02 :	1	2.5	2.4

Although no cases were studied within the first fifteen days after the operation, the data at hand indicate that injury may produce a temporary stimulating effect on cellular production. This is suggested by the fact that in case E. Ext. 9 (sixteen days after operation) 23 per cent more cells were found in the injured side than on the normal side, but in the older cases studied the cellular ratios between the injured and the uninjured sides were found to be practically 1–1 (table). If the increased number of cells found in the younger animal (sixteen days after operation) is an expression of the stimulating effects of injury, it would appear that such temporary increase in the cellular production is compensated for

by a retardation in older stages, otherwise one would expect cellular differences between the two sides of the medulla in the older cases examined. Since this was not found, it is suggested that cellular increases which may result from repair processes in experimental injury to the nervous system have no appreciable effects upon the final production of cells. The results of these and other experiments seem to fall in line with Coghill's ('24) observations that there is a certain potential for cellular production in various regions. It is suggested, however, that if injury hastens cellular proliferation, the acceleration is compensated for by a subsequent retardation, so that the eventual cell number approximates the normal. If this hypothesis is sound, there seems justification in the conclusion that the hyperplastic development of the various nerve centers, when in connection with a transplanted eye, cannot be ascribed to influences resulting primarily from injury. In this respect, the results of the experiments on the medulla are in correspondence with those on the spinal cord where it was shown also (Detwiler, '25 c) that injury could not have been an important agent in producing the hyperplasias described. In all previously cited cases in which hyperplasias were found in various grafted portions of the central nervous system (Detwiler, '23 a, '23 b, '25 a, '25 b), the larvae were between thirty and sixty days old—an age which falls considerably beyond that in which cellular increases resulting from injury are suggested (case E. Ext. 9, table).

Although the evidence from the cases studied suggests the possibility of a temporary increase in cellular proliferation as a result of injury, with a compensating retardation in cellular production, no data are as yet available regarding the reactions of the cells to injury during the first fifteen days. Experiments have been carried out, however, with the view of studying particularly the condition during this early period, and it is hoped that a more complete account of the effects of injury may be forthcoming. It should be noted here that Hooker ('25) described increased cellular mitoses

in the vicinity of the wound, following transection of embryonic frog spinal cords, but he does not discuss the wound healing reactions from the viewpoint of permanent cellular increases.

Although a greater number of cells was counted on the normal side of the medulla in the sixteen-day larva than in the older cases (table), this is no doubt due to the fact that the cells are smaller and thus more were recounted. The marked difference in the number between sixteen days and twenty-one days indicates that growth of the cells is proceeding much more rapidly during this period than after twenty-one days. That growth is taking place very slowly after the latter period (twenty-one days) is indicated by the fact that the difference between the number counted at twenty-one days and forty-two days is very small. Indeed, it appears quite striking that, in the older cases listed, the differences are extremely small, which seems suggestive of a constant cell number.

CONCLUSIONS AND SUMMARY

When the medulla of Amblystoma embryos is experimentally injured by cutting a small hole into the lateral wall, there is no evidence suggesting a permanent increase in the proliferation of cells resulting from the injury. There is some indication that injury in some cases may bring about a temporary increase in cell proliferation. This is shown by a considerable difference in the cell counts between the injured wall and the contralateral normal wall in a larva of sixteen days (E. Ext. 9, table). Since in older larvae (twenty-one, forty, and forty-two days) a comparison between the injured side and the normal side yields practically equal cell numbers for a given region, it is suggested that if temporary acceleration in cell production does result from injury, it is compensated for by a secondary retardation.

The complete lack of numerical differences between the cells of the injured side and the normal side of the medulla in older larvae (twenty-one to forty-two days) appears to justify

former conclusions that various hyperplasias which have been described previously in the nervous system of Amblystoma (Detwiler, '23, '25; May and Detwiler, '25) must be looked upon as resulting from influences other than those brought about by injury.

BIBLIOGRAPHY

Burr, H. S. 1923 Experimental hyperplasia of the cerebral hemispheres in Amblystoma. Anat. Rec., vol. 25, p. 121.

———— 1924 Hyperplasia in the brain of Amblystoma. Proc. Soc. Exp. Biol. Med., vol. 21, pp. 473–474.

Coghill, G. E. 1924 Correlated anatomical and physiological studies on the growth of the nervous system in Amphibia. IV. Rates of proliferation and differentiation in the central nervous system of Amblystoma. Jour. Comp. Neur., vol. 37, pp. 71–120.

Detwiler, S. R. 1923 a Experiments on the transplantation of the spinal cord in Amblystoma, and their bearing upon the stimuli involved in the differentiation of nerve cells. Jour. Exp. Zoöl., vol. 37, pp. 339–393.

———— 1923 b Experiments on the reversal of the spinal cord in Amblystoma embryos at the level of the anterior limb. Jour. Exp. Zoöl., vol. 38, pp. 293–321.

———— 1925 a The results of substituting an extraneous medulla for the cephalic end of the embryonic spinal cord in Amblystoma. Jour. Exp. Zoöl., vol. 41, pp. 293–347.

———— 1925 b An experimental study of cellular proliferation in the anterior portion of the spinal cord of Amblystoma. Jour. Exp. Zoöl., vol. 42, pp. 333–370.

———— 1925 c Spinal cord injury and nerve cell proliferation in the embryo. Anat. Rec., vol. 30, pp. 297–303.

Hooker, Davenport 1915 Studies on regeneration in the spinal cord. I. An analysis of the processes leading to its reunion after it has been completely severed in frog embryos at the stage of closed neural folds. Jour. Comp. Neur., vol. 25, pp. 469–495.

———— 1925 Studies on regeneration in the spinal cord. III. Reestablishment of anatomical and physiological continuity after transection in frog tadpoles. Jour. Comp. Neur., vol. 38. pp. 315–347.

May, R. M., and Detwiler, S. R. 1925 The relation of transplanted eyes to developing nerve centers. Jour. Exp. Zoöl., vol. 43, pp. 83–103.

THE VARIOUS ELEMENTS IN THE EPITHELIUM OF THE FUNDIC MUCOSA, WITH SPECIAL REFERENCE TO THOSE CELLS WHOSE ENTODERMAL ORIGIN IS DOUBTFUL [1]

ALDEN B. DAWSON
Department of Biology, New York University

During the past few years, several so-called new types of cells have been described for the glands of the fundic mucosa. There are also other elements which have been referred to briefly by earlier workers, but whose significance is still more or less problematical. Recent work has also indicated that some of the cellular elements described as epithelial are not of entodermal origin, but have migrated into their position in the epithelium and presumably are of mesodermal origin, probably derivatives of certain cells of the connective tissue. Parasitic protozoa may possibly also occur in the epithelium and simulate an epithelial element. Modern text-books of histology usually fail to make any adequate mention of certain of these structures, and it is the desire of the author in this paper to summarize and to attempt to correlate the scattered observations made on the many types of cells described as occurring in the fundic mucosa.

Four types of cell are generally recognized in the fundic mucosa, 1) the tall columnar cell of the free surface and the more superficial portion of the crypt; 2) more cuboidal cells of the 'neck' (Bensley, '98), 'cellules principales du col' (Cade, '01); 3) chief cells, 'Hauptzellen' of Heidenhain ('70), and, 4) the parietal cells, 'Belegzellen' of Heidenhain ('70).

Heidenhain also noted another granular element of irregular distribution, which has subsequently been referred to as

[1] Based chiefly on histological studies, by the author and others, on the stomach of the dog.

the granular cell of Heidenhain. In his description he states: "Sie liegen in der Regel an der Schlauchperipherie drängen sich aber auch hier und da zwischen die Hauptzellen ein." "Denn sie kommen regellos sowohl bei hungernden als bei starkgefütterten Thieren bald ganz einzelen, bald etwas häufiger, bald in vielen Schläuchen gar nicht vor."

Still another cell was described by Harvey ('07) as occurring in the deeper part of the gland—a chromaffin cell which gave the yellow color reaction following a fixing fluid containing potassium bichromate. He felt this was a variety of parietal cell, whose granules, due to some physical or chemical difference, gave the chromaffin reaction. These cells are probably the same as those described earlier by Popoff ('97), but his description is not complete enough to warrant a definite statement to this effect. More recently, Lim ('22) has emphasized the rather widespread occurrence of a so-called 'mucoid' cell which was recognized, but not adequately treated by Bensley in 1898. In 1924, Twort reported what he believed to be a hitherto undescribed type of cell which gave a peculiar staining reaction with neutral red and light green following fixation in Muller's fluid. In 1925, the author noted a decided difference in the staining reactions of certain parietal cells, but attributed the difference to certain unascertained functional changes possibly induced by irradiation. Later, the Laroches ('26) reported the existence of two types of parietal cell in the fundic mucosa of the dog.

The four familiar types of cells need not be discussed further. The others will be taken up in what appears to be a logical order. First, the mucoid cell of Lim; second, the atypical parietal cell of the Laroches; third, the chromaffin cell of Harvey, and, fourth, the granular cell of Heidenhain.

According to Lim, the mucoid cells occur in the fundus, being most marked in the boundary zones, where they are continuous with the cardiac cells on one side and the pyloric cells on the other. They are intermingled with the peptic and oxyntic cells, but chiefly occupy the superficial or upper part of the gland tube. He believes the mucoid cells are

undoubtedly a definite variety of the gastric gland cells and that they are closely allied to the peptic cells to which they give rise in early and perhaps in later life; but although the mucoid cell gives rise to the peptic cell, the latter is not to be regarded as merely a functional phase of the former. The mucoid cell of the fundus, according to Lim's view, forms the lowest functional type.

His conclusions, however, are quite different from those of Kirk ('10), who studied the histogenesis of the gastric glands in the pig. Kirk bases his conclusions on the ontogenetic relation of mucous and chief cells of the cardia. The cardia represents a part of the fundus which has undergone partial involution, so that the cardiac glands are not primitive, but regressive structures. He believes that, in the phylogenetic transformation of the fundic portion of the cardiac tubule, both zymogenic and parietal cells were dedifferentiated into chief cells of the mucous type. In ontogeny Kirk did not observe the transformation of the parietal cell, but did observe the process in the chief cell. He accordingly distinguishes in the differentiated cardia two types of mucous cells, those of the foveolar and neck region, which are palingenetically mucous, and those of the gland fundus, which are coenogenetically mucous, having passed, in race history, through zymogenic or parietal stages. Moreover, he found that in the fundus those cells destined to be zymogenic chief cells did not pass through a mucous stage and in the pylorus all the mucous cells differentiated directly from unmodified epithelial cells. The possibility of dedifferentiation of the specialized zymogenic cells of the fundus was demonstrated by the earlier experimental work of Cade ('01) and Harvey ('07) in which it appeared that, under the conditions of their experiments, these cells of the fundic mucosa underwent a mucous regression. Harvey also pointed out that the mucous transformation was not always an irreparable retrogressive change, since these cells in some instances reassumed their original function of ferment production, the complete cycle of reversals taking place in six

months. The distribution of the mucoid cells, most numerous at the two boundary zones of the fundus, leads one to question Lim's interpretation of their significance. In other words, their occurrence in the fundic tubules may indicate regressive rather than progressive changes. Accordingly, the mucoid cells may not represent a distinct type of cell, but may be regarded either as displaced cells of the chief mucous type normally limited to the other regions of the stomach or as true cells of the fundus of the adult stomach undergoing retrogressive changes similar to those occurring in embryonic development of the cardiac mucosa. Accordingly, the only mucoid cells which are able to differentiate into pepsinogen chief cells are those formed by a mucoid degeneration of pepsinogen cells (Harvey, '07; Kirk, '10).

Laroche and Laroche ('26) state rather categorically that there are two definite types of parietal cells in the fundus of the dog. They urge as evidence in favor of this view that both types are present in the same portion of tissues at the same time and in either functional stage, i.e., whether the animal is fasting or the stomach full. However, there is no positive evidence that, in the active phase, at least, all cells are in the same phase of activity at the same moment and there is some experimental evidence which indicates that this is not the case (Dawson and Ivy, '25). The cell of type 2 is irregularly distributed and may be either oval, flattened, or biconcave in section. The nucleus is homogeneous, stains densely, and sometimes may possess sharp processes which extend into the cytoplasm and around which the granules are oriented. There is a clear perinuclear zone, and a peripheral condensation of granules is present. The granules stain black in iron haematoxylin. The most characteristic feature of the parietal cell, the intracellular canaliculi, is not mentioned. Unfortunately, their paper is not illustrated.

The author ('25), while studying the stomach of dogs following irradiation, noted two variations in the staining reactions of the parietal cells. With iron haematoxylin the cytoplasmic granules of some cells remained practically

unstained, while those of other cells stained intensely. The nuclei of the faintly stained cells were homogeneous and stained densely, while the cells with blackened granules exhibited a definite chromatic reticulum, usually with a karyosome. The variations in the staining reaction of the parietal cells could not be correlated with any definite functional state.

It is difficult to decide whether the two types of parietal cells described by Laroche and Laroche are the same as those described by me. It appears possible that the atypical parietal cells of the French authors are to be identified with the granular cells of Heidenhain, which will be discussed later in this paper.

Chromaffin cells in the stomach of the dog were recognized by Harvey ('07), who believed they represented modified parietal cells. Since then they have been recognized by many workers, and recently have been studied intensively by Kull ('25) and Hamperl ('25). Kull finds the chromaffin cells usually have an acidophilous stage, are derived from cells of connective tissue, and migrate into the epithelium. They may represent true chromaffin cells such as are found in the suprarenal glands. Hamperl ('25) adds little to the findings of Kull, but discusses the 'new cell' described by Twort ('24), which he feels belongs to this group of granular or yellow cells. Hamperl suggests that the term 'chromaffin' be restricted to such cells as those in the medulla of the suprarenal, since the function of these yellow granular cells is not known and their possible participation in the production of an internal secretion is still unproved.

Besides these granular cells which may give a chromaffin reaction when completely differentiated there are also other cells which possess much coarser granules or globules. These have been recognized and their staining reactions studied by Weill ('19), Lim ('22), and Keasberg ('23). These cells, 'Schollenleukozyten' of Weill, may often be found within the gastric epithelium and simulate true epithelial elements. Little is known regarding the origin and relationships of these

cells, and Maximow ('25) discusses several possibilities based chiefly on the researches of Samssonow ('09), Solucha ('08), and Schwarz ('14). They are doubtless derived from some of the cellular constituents of the connective tissue.

Other small granular cells first noted by Heidenhain ('70) were observed by Harvey and Bensley ('12) while studying the reaction of parietal cells, in excised portions of the fundic mucosa, immersed in either a solution of cyanamin bichloride or neutral red. In cyanamin bichloride the granules were stained blue, and in neutral red they also showed an acid reaction. Cyanamin bichloride gives a decided blue color reaction at a pH of 3'0 (Dawson and Ivy, '26), while neutral red is crimson at a pH of 6'8. These observations of Harvey and Bensley can be readily confirmed (Dawson and Ivy, '26) and demonstrate conclusively that the granules of the Heidenhain cells are decidedly acid in their reaction.

Rous ('25), in a series of studies on the relative reaction within living tissues, discovered that certain granular cells, especially of the connective tissues, gave an acid reaction with both litmus (pH 4'5) and bromphenol blue (pH 3'0). Many of these granular cells he identified with tissue macrophages. Occasionally scattered, ovoid, or pyriform variants from these cells were observed, with small, eccentrically placed nuclei. These cells are so crowded with lightly stained granules that the cytoplasm as a whole has the appearance of pink ground-glass (litmus staining). He states that they can scarcely be wandering macrophages, for the latter cells are, at this period in the experiment, filled with stained granules which are deep pink or red, and coarse, some of them being as large as erythrocytes. These cells were also present in the connective tissues of the stomach and intestine.

While studying the reaction of the parietal cells in excised portions of the mucosa with neutral red (Dawson and Ivy, '26), we were struck by the similarity, in appearance and staining reactions, of certain granular cells (Heidenhain's) adjoining or in the gastric epithelium, to other cells lying deeper in the tunica propria. It is also significant that the

degree of acidity in the granules of Heidenhain cells stained with cyanamin bichloride is the same as that of the granules of the connective-tissue elements studied by Rous with bromphenol blue (pH 3'0). It seems possible, therefore, that the cells noted by Heidenhain are also derivatives of cells in the connective tissue which migrate into the gastric epithelium and assume an epithelioid form. They may be stages in the differentiation of the yellow granular or chromaffin cells.

From this comparative survey of the various elements described as constituents of the gastric fundic mucosa, it appears that all but five probably have a mesodermal origin. The true entodermal derivatives are, 1) the tall columnar cells of the free surface and crypt; 2) the more cuboidal cells of the neck; 3) the pepsinogenic chief cells; 4) the parietal cells, and, 5) the mucoid chief cells representing either a progressive stage (Lim, '22) or a retrogressive stage (Harvey, '07; Kirk, '10) of the pepsinogenic chief cell.[2] The other cells, 1) the chromaffin cells of Harvey, 2) the new type of cell of Twort, 3) the so-called atypical parietal cells of Laroche and Laroche, 4) the coarse granular or globular cells (Schollenleukozyten of Weill), and, 5) the granular cells of Heidenhain, are probably mesodermal derivatives representing specialized cells of the connective tissue. Twort's cell may be identified with the chromaffin or yellow cell. The cells of Laroche and Laroche are probably identical with the granular cells of Heidenhain, which may represent stages in the differentiation of the yellow cells. The coarse granular or globular cells are probably unrelated to any of these and represent special wandering elements of obscure origin.

Since the above summary was written, a paper by Cordier ('26) has appeared in which he has made an intensive study of the chromaffin cells of the small intestine. He utilized,

[2] Ferguson ('27) concludes that mucous chief cells are capable of giving rise to more mucous chief cells or, by further differentiation, they may transform into parietal cells or serous chief cells. Ferguson, A. N., 1927, An analytical study of regeneration in the gastric mucosa of the dog. Anat. Rec., vol. 35, p. 37 (abstract).

in addition to the chromaffin reaction, the silver reaction of Masson ('14). Cordier found nothing to support Kull's view of a non-entodermal origin for these cells and has marshaled evidence in favor of their entodermal derivation. He feels that Kull, without the aid of the silver reaction, has confused leucocytes with differentiating chromaffin cells. Since Kull homologizes the chromaffin cells of the intestine with those of the stomach, Cordier's criticism applies equally well to Kull's view regarding the cells under discussion in this paper. Cordier's contradictory findings reopens the question, which appeared to be settled, as to whether it is possible for a mesodermal element to become fixed and to function in the gastric epithelium of entodermal origin.

LITERATURE CITED

Bensley, R. R. 1896 The physiology and histology of the gastric glands. Proc. Canad. Inst., vol. 1, pp. 11–16

———— 1898 The structure of the mammalian gastric glands. Quart. Jour. Micr. Sci., N. S., vol. 41, pp. 361–389.

———— 1904 Stomach. Reference handbook of medical science, vol. 7, p. 942.

Cade 1901 Étude de la constitution histologique normale et de quelques variations functionelles et expérimentales des éléments sécreteurs des glandes gastriques du fond chez les mammifères. Arch. d'Anat. micr., T. 4, pp. 1–86.

Cordier, R. 1926 Recherches morphologiques et expérimentales sur la cellule chromo-argentaffine de l'épithélium intestinal des vertébrés. Arch. de Biol., T. 36, pp. 427–463.

Dawson, A. B. 1925 Histological changes in the gastric mucosa (Pawlow pouch) of the dog following irradiation. Am. Jour. Roentg. Rad. Therapy, vol. 13, pp. 320–326.

Dawson, A. B., and Ivy, A. C. 1926 Formation of hydrochloric acid by the gastric mucosa. Am. Jour. Physiol., vol. 76, pp. 158–169.

Hamperl, H. 1925 Ueber die gelben (chromaffine) Zellen im Epithel des Verdauungstraktes. Zeitschr. f. mikr. Anat. Forsch., Bd. 2, S. 506–535.

Harvey, B. C. H. 1907 A study of the structure of the gastric glands of the dog and of the changes which they undergo after gastro-enterostomy and occlusion of the pylorus. Am. Jour. Anat., vol. 6, pp. 207–243.

Harvey, B. C. H., and Bensley, R. R. 1912 Upon the formation of the hydrochloric acid in the foveolae and on the surface of the gastric mucous membrane, and the non-acid character of the contents of the gland cells and lumina. Biol. Bull., vol. 23, pp. 225–249.

HEIDENHAIN, R. 1870 Untersuchungen über den Bau der Labdrüsen. Arch. f. mikr. Anat., Bd. 6, S. 368.

KEASBERG, L. E. 1923 On a new form of leucocyte (Schollenleukozyt, Weill) as found in the gastric mucosa of the sheep. Fol. Haemat., Bd. 29, S. 155–171.

KIRK, E. G. 1910 On the histogenesis of gastric glands. Am. Jour. Anat., vol. 10, p. 473.

KULL, H. A. 1925 Die chromaffin Zellen des Verdauungstraktus. Zeitschr. f. mikr. Anat. Forsch., Bd. 2, S. 163.

LAROCHE, M. ET MME. 1926 Sur l'existence de deux types de cellules bordantes dans les glandes du fond de l'estomac. Compt. Rendu. Soc. Biol., T. 94, p. 362.

LIM, R. K. S. 1922 The gastric mucosa. I. The gastric mucosa of the cat. II. The gastric mucoid-cells of foetal and newborn animals. III. The gastric mucoid cells in man, dog, rabbit, and frog. Quart. Jour. Micr. Sci., vol. 66, pp. 187-212.

MASSON, P. 1914 La glande-endocrine de l'intestine chez l'hommes. C. R. Acad. Sc., 5 jan.

MAXIMOW, A. A. 1924 Relation of blood cells to connective tissues and endothelium. Physiol. Rev., vol. 4, pp. 533–563.

POPOFF 1897 Ueber Magenkatarrh. Ztsch. f. klin. Med., Bd. 32, S. 389.

ROUS, P. 1925 On the mobilization of acid material within cells, and the reaction as influenced by cell state. Jour. Exp. Med., vol. 41, pp. 399–411.

SAMSSONOW, N. 1909 The wandering cells of the intestinal mucosa in mammals. St. Petersburg, Inaug. Dissert. Abstract, Fol. Haemat., vol. 8, p. 227.

SCHWARZ, E. 1914 Ergebn. d. allg. Path. u. path. Anat., Bd. 17. (Cited from Maximow, 1924.)

SOLUCHA, N. 1908 On the cells of the connective tissue of birds in normal conditions and in inflammation. St. Petersburg, Inaug. Dissert. Abstract Fol. Haemat., vol. 8, p. 230.

TWORT, F. W. 1924 The demonstration of a hitherto undescribed type of cell in the glands of the stomach. Br. Jour. Exp. Path., vol. 5, pp. 352–353.

WEILL, P. 1919 Ueber die leukozytären Elemente der Darmschleimhaut der Säugetiere. Arch. f. mikr. Anat., Bd. 93, S. 1.

ADVANCE NOTICE FROM THE SECTION FOR EXPERIMENTAL CYTOLOGY OF THE TENTH INTERNATIONAL CONGRESS OF ZOÖLOGISTS AT BUDAPEST, 1927

The ninth International Congress of Zoölogists, which was held in March, 1913, at Monaco, decided to have its tenth session in 1916 at Budapest, under the chairmanship of the undersigned. War conditions made it, unfortunately, impossible to adhere to the date determined upon for 1916, and the session of the tenth congress had to be postponed. The present international situation, however, now permits of this congress being held next year.

I have the honor, therefore, with the approval of the Permanent Committee of the International Congress of Zoölogists, to announce that its tenth congress will be held at Budapest from the fourth to ninth of September, 1927, inclusive, and that all zoölogists and friends of zoölogy are most cordially invited to attend.

In addition to the sections already represented at past congresses, a section for experimental cytology will be inaugurated at this time.

The complete program of the Congress will be issued during the course of the year and sent to all those interested.

Dr. G. Horváth,
President Tenth International Congress of Zoölogists.

Hungarian National Museum,
Budapest, September 4, 1926.

A few additional remarks concerning the next to last paragraph of the above announcement are necessary.

The new section for experimental cytology came into existence in the following way: Prof. G. Levi, of Turin, and Prof. Rhoda Erdmann, of Berlin-Wilmersdorf, were desirous of meeting with other cytologists from Europe and elsewhere, so that this newly created special branch might correlate its discoveries with those of the older branches.

This new section for experimental cytology is composed of investigators who already belong to other scientific societies, but who are particularly engaged in experimental cytology. They are founding no new society, but have, instead, chosen this way of becoming associated with the International Congress of Zoölogists as a section, in order to make possible an understanding of the aims, discoveries, and methods of experimental cytology. This was made possible by the cooperation of the president of the Tenth Congress, Professor Horváth, and the chairman of the Budapest Local Committee, Professor von Lenhossék.

Invitations to join the sessions of the Section for Experimental Cytology follow, together with that to the Tenth International Congress of Zoölogists. They are directed not only to those investigators who are engaged in tissue culture, but to all cytologists who have busied themselves over metazoan, metaphytic, and protozoan cells and have studied these by methods of vital staining, microdissection, or tissue culture, and have by these means come to any conclusions concerning living cells.

The tentative program for the session of the Tenth International Congress of Zoölogists, at Budapest, in 1927, is as follows (the subjects of the lectures are merely outlined):

September 3rd, Saturday. Social evening of welcome.

September 4th, Sunday. Opening session.

September 5th, Monday. *Morning*—Joint session of Section on Experimental Cytology with all the sections. Lecture by Prof. R. G. Harrison, New Haven, "On the status and significance of tissue culture." *Afternoon*—Special session of Section on Experimental Cytology. Lecture on "The behavior of plant cells in vitro and in vivo," by Prof. E. Küster,

Giessen. Other lectures on similar topics, discussion. Demonstrations particularly desirable.

Sessions of the Section on Experimental Cytology. September 6th, Tuesday. *Morning*—Session opened by Prof. G. Levi, Turin: "The structural behavior of living tissues under culture." Other lectures on similar topics. *Afternoon*—Session opened by Dr. Alexis Carrel, New York: "Modern techniques of tissue culture and results." Other lectures on similar or associated topics. Discussion and demonstrations.

September 7th, Wednesday. *Morning*—Session opened by Prof. Rhoda Erdmann, Berlin-Wilmersdorf, and Prof. A. A. Krontowski, Kief: "What has tissue culture accomplished toward the solution of problems in pathology, particularly those of cancer and immunization?" Other lectures on similar topics. *Afternoon*—Session opened by Prof. N. Chlopin, Leningrad, and Prof. A. Timofejewsky, Tomsk: "The origin of blood, connective tissue, and related cell types." Other lectures on similar subjects, with discussions. Demonstrations desirable.

September 8th, Thursday. *Morning*—Session opened by Professor von Möllendorf, Kiel: "Vital staining and experimental cytology." Other lectures along similar lines. *Afternoon*—Subject: "Microdissection," lecturer not yet chosen. Lectures along similar or related lines; discussion. Demonstrations.

September 9th, Friday. Closing session.

September 10th, Saturday. Excursion to Plattensee and inauguration of the new biological station in Tihany, on the Plattensee.

September 11th, Sunday. Optional joint excursion to Debrecen and the Hortobágyer Steppe.

Cesare Artom, Pavia; H. Carleton, Oxford; N. Chlopin, Leningrad; A. H. Drew, London; Rhoda Erdmann, Berlin-Wilmersdorf; M. Fauré-Fremiet, Paris; Albert Fischer, (temp.) Berlin-Dahlem; A. Gurwitsch, Moscow; Nicolas Koltzoff, Moscow; A. A. Krontowski, Kief; Ernst Küster,

Giessen; Giuseppe Levi, Turin; R. Policard, Lyons; G. Roussy, Paris; Armin Tschermak-Seysenegg, Prague II; Emilio Veratti, Pavia; A. Wallgren, Helsingfors.

Note 1. The lectures will be given in all four official languages of the Congress.

Note 2. Prof. Rhoda Erdmann, Berlin-Wilmersdorf, Nassauischestr. 17, II, editor of the "Archiv für experimentelle Zellforschung," is now receiving announcements of lectures, demonstrations, and any suggestions. Other questions, such as the provision of microscopes, the possibility for projection, etc., should be directed to the Secretary of the Local Committees, Privatdozent Dr. L. Karczag, Budapest III, Klinik für innere Medizin, VIII. Ludòvinumgasse 2. Hotel reservations, transportation, and passports will be attended to by the local committee, to which direct applications should be made.

THE HOMOLOGIES OF THE ARM AND LEG

M. R. DRENNAN

The Anatomy Department of the University of Capetown

EIGHT FIGURES

The general morphological resemblance between the arm and leg is obvious, but when attempts are made to draw a detailed comparison between them there is great diversity of opinion as to what are corresponding structures. This is not to be wondered at, seeing that anatomists are not agreed as to the basis on which the comparison must be made. Moreover, the modifications in each limb, adapting it to its special function, have considerably blurred the resemblance between them. Especially is this the case in the human arm and leg, so that a comparison between these is particularly difficult, yet it is largely from a study of their affinities that deductions have been drawn and applied to other vertebrates. It is important, therefore, on this account that anatomists should try to reach some agreement as to the nature of the relationship which exists between the arm and leg. Until this is done, it seems idle to go into very great detail in the comparison, and there is a danger of attempting to establish homologies where none exist.

SERIAL HOMOLOGY

The orthodox view on this matter, for which Flower(1), Huxley(2), and others, are largely responsible, is that the arm and leg are serially homologous, and it is comparisons made on this interpretation, which are incorporated in the various text-books, which allude to this subject. In demonstrating this method of comparing the limbs it is usual to

extend them at right angles to the axis of the body in a position as similar as possible to that occupied by them in the primitive and embryonic condition. That is to say, the borders containing the thumb and big toes are directed toward the head, while the other borders are directed caudally. At the same time the extensor groups of muscles in each limb look dorsally, while the flexor groups look ventrally.

The cranial border of each limb is called the preaxial border, and the caudal border is called the postaxial border, these terms being used in reference to the axes of the limbs themselves. The flexor muscles are referred to by some authors as preaxial and the extensors as postaxial in reference to the axis of the trunk, but in this paper these terms will not be used in this latter, but always in the former sense.

According to this serial view of the relationship between the limbs, structures situated on the preaxial border of one limb are considered to be homologous to structures on the preaxial border of the other limb, and so for the postaxial borders. That is to say, the arm is regarded as the exact morphological counterpart or cast of the leg of the same side, and both limbs from the same side of the body could be fitted into the same type of mold (fig. 1).

SYMMETRICAL HOMOLOGY

Another view, which is held by a small minority of anatomists, notably Humphrey(3), Parsons(4), Geddes(5), and Keith(6), but which has found little support in the text-books, is that the arm is symmetrically homologous to the leg. According to this view, there is a relationship between the arm and leg of the same nature as exists between a right limb and a left limb. That is to say that, just as there is a bilateral symmetry in the body manifesting itself by each limb being the mirror image of its fellow, so there is a craniocaudal or biterminal symmetry which is expressed in a mirror image or symmetrical homology between the forelimb and the hindlimb on each side.

Viewed in this light, the preaxial border of the arm must be homologized with the postaxial border of the leg. Accordingly, Geddes has designated these borders as being apomphalic, or distal to the umbilicus, while he refers to the other two comparable borders of the limbs as paromphalic (figs. 1 and 2).

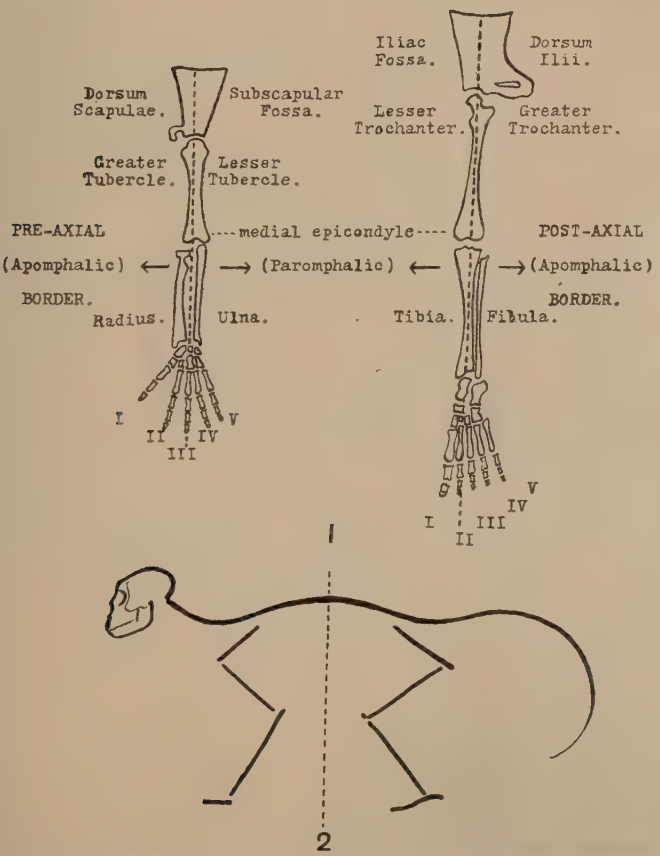


Fig. 1 Diagrammatic representation of the bones of the arm and leg to show homologous parts.

Fig. 2 Diagram showing the biterminal symmetry between the arm and leg of a primate.

DISCUSSION OF THE TWO HOMOLOGIES

The author of the present paper is unable to accept the theory of serial homology as usually applied to the limbs, and he advocates the substitution of the theory of symmetrical homology for this serial interpretation in any comparison which is instituted. With this object in view, an adverse criticism of the serial theory is submitted, and a detailed comparison is made between the arm and leg on a symmetrical basis. Previous writers have only adumbrated this view, or they have applied it merely to one part of the limbs. In the present paper the full implications of comparing the arm and leg on this interpretation are worked out. The results show clearly that a morphological symmetry exists and that it must be regarded as a very important factor in any comparative study of the forelimb and the hindlimb.

Before dealing with this latter relationship, it is necessary to refer briefly to some of the unsatisfactory features of the serial theory. The foundation of this interpretation of the homology of the limbs is the assumption that, because of their general resemblance, the thumb and the big toe are homologous. This correspondence is usually taken for granted, but it will be shown later that the homology of the pollex and hallux is not only not beyond all doubt, as Huxley thought, but that it is even highly problematical. Starting from this supposed homology of the thumb and big toe, it is asserted that structures on the thumb (preaxial) border of the arm are morphologically related to structures on the big toe (preaxial) border of the leg. The following are some of the unsatisfactory consequences of the application of this debatable criterion of comparison.

Thus it postulates that the ventral subscapular fossa, with its one muscle lying in front of the long head of the triceps, is homologous to the dorsal surface of the ilium, with its several muscles lying behind the long head of the quadriceps (rectus femoris). The greater tubercle of the humerus, with its three muscle attachments, is homologized to the lesser trochanter of the femur with its single tendon attachment.

The undoubtedly homologous triceps and quadriceps muscles go to bones which are not homologous on the serial interpretation, namely, to the ulna and the tibia, respectively. The biceps muscles are inserted into the radius and the fibula, respectively, yet these are not regarded as homologous bones. The medial epicondyle of the humerus, from which the flexor group of muscles arises, is likened to the lateral epicondyle of the femur, from which the extensors arise in most animals. The flexor pollicis longus arises from the radius, whereas the flexor hallucis longus arises from the fibula, yet these are non-homologous bones, according to the serial interpretation.

It is customary to adduce different functional requirements as the explanation of all these and other anomalies in the structural correspondence. At the same time numerous rotations and tortions, some ingenious and others clumsy, have been postulated to account for the discrepancies in the comparison, but not one of these seems to be an adequate explanation. Again the well-known plasticity of muscles and their capacity for migration has been a convenient method of explaining the wholesale 'migrations' indicated above. Further, there is no end to the chaos which may be introduced by this theory, because of the difficulty of knowing in each anomalous instance cited whether it is the arm or the leg which has remained true to type or has become modified. That is to say, it is difficult to decide, for example, whether it is the tubercles of the humerus or the trochanters of the femur which have become reversed from the fundamental plan.

Nothing in the above criticism of the unsatisfactory and unacceptable results from a serial comparison or of the explanations of its modification, which are usually adduced, is to be taken as in any way indicating that the author does not accept the well-known and simple rotations by means of which the embryonic limbs gradually assume the foetal and adult positions. These changes in position are generally accepted, but they do not account for any of the above discrepancies.

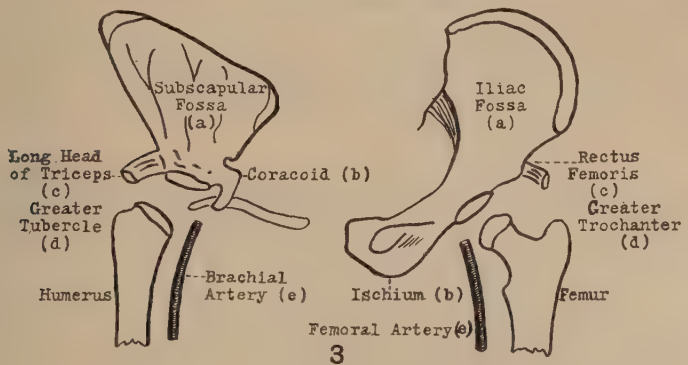
In seeking for a true standard of comparison between the limbs, one is struck by the fact that when a preaxial structure in one limb does not resemble in form a corresponding preaxial structure in the other limb it does resemble the postaxial structure in that limb. This suggests the possibility of an exactly opposite relationship being the fundamental one or at least the chief modifying factor in the morphology of the limbs. According to this view, which has been already alluded to as a biterminal symmetrical homology, preaxial (apomphalic) structures in one limb correspond to postaxial (apomphalic) structures in the other limb.

Bilateral symmetry is the modification which nature has adopted to enable the right and left limbs to take an equal share in balancing the body weight around the center of gravity. It would be very surprising if there was not something analogous in the relationship between the forelimb and the hindlimb of each side to enable them to support each end of the body and thus complete the balance round the center of gravity (fig. 2). If this reason for a biterminal symmetry exists in quadrupeds, and it should be noted here that the possession of just four limbs is a fundamental characteristic of the vertebrates, there is no reason to doubt its applicability to a comparison of the human limbs.

If this conception is applied to a study of the arm and leg, the first and most striking result is to get rid of practically all the difficulties encountered in applying the serial comparison. Figure 3 shows the bony parts in the region of the left shoulder compared with the corresponding parts in the left pelvic girdle. No less striking is the likeness presented by the left shoulder muscles to the left pelvic muscles in figure 4. In figure 5 the similarity between the triceps and the quadriceps is obvious, and they are inserted into bones which on a symmetrical basis are homologous. The long head of the biceps femoris corresponds to the short head of the biceps brachii. The short head of the biceps femoris is represented by the occasional third head of the biceps brachii. The biceps muscles are inserted into the radius and the fibula, respec-

tively, in the arm and leg, and these are symmetrically homologous bones.

As we proceed toward the distal extremity of each limb, the symmetry becomes more blurred. This is largely because,



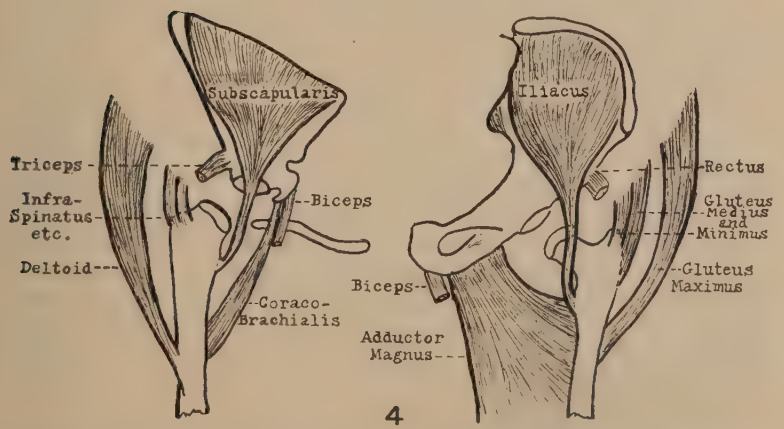


Fig. 3 Corresponding parts a, b, c, etc., in the left shoulder and pelvic regions.
Fig. 4 Corresponding muscles in the left shoulder and pelvic regions.

according to this basis of comparison, the thumb has to be homologized with the little toe, and the little finger with the big toe. At first sight, this appears to be a difficult homology to sustain, but in reality a comparison of the forearm and

hand in one limb with the leg and foot in the other limb is more harmonious on this interpretation than on the serial one. Most attempts to homologize the limbs on even a serial basis have broken down in the muscles of these regions. It is necessary to concede, however, that there is a greater apparent resemblance between the thumb and the big toe than between the thumb and the little toe, but this can be accounted for by regarding it as a secondary modification of a functional nature. In Geddes'(5) opinion—

> the evidence available from the nervous system goes to show that secondarily, that is subsequent to the establishment of the dominance of the segmented cephalised part of the body, when the limbs are required to function as part of an animal with a definite head and tail, the great toe approximates in type to the thumb, taking over from the thumb's real homologue, the little toe, a sufficiency of its nerve supply and of its musculature fully to equip it for its new position (cf. apomphalic, fibular, origin of flexor hallucis longus). In other words, the correspondence between the thumb and great toe is an example of heterogeneous homoplasy.

There is no evidence of this cephalization of the hand and foot having affected the preaxial borders of the limbs more proximally, as is assumed by the theory of serial homology. Even in the hand and foot this cephalization is by no means a constant feature of the vertebrate organization. In the very large group of animals in which certain of the digits have been sacrificed for functional purposes, it is usually the pollex and the hallux which are the first to go, showing that these are the least stable of all the digits, and therefore the least reliable of all the digits as a foundation for a morphology applicable to the rest of the limb.

Nor is there any evidence that in the origin and development (phylogeny and ontogeny) of the limbs there is any definite serial modification. The arm and leg buds have a very similar origin in the embryo in close relationship to a definite but different number of segments in each case, but it is still a matter of dispute as to how far, if at all, the somites enter into the early constitution of the limbs, so that

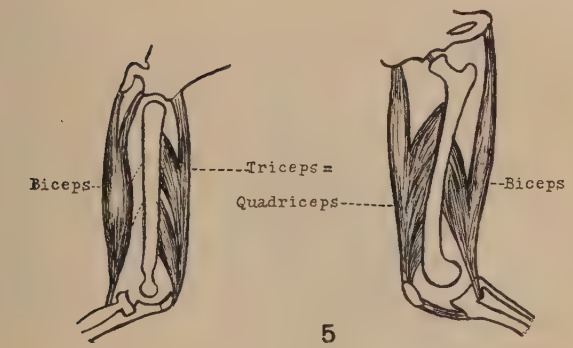
arguments based on the origin and early development of the limbs are of doubtful value at the present juncture. Certainly, so far as our present knowledge goes, there is no reason to regard the preaxial part of the one limb bud as corresponding more to the preaxial than to the postaxial part of the other limb bud, except as regards situation and the later thumb and big-toe modification. In this connection Geddes(5) has, in fact, advanced a theory as regards the origin of the limbs, which considers them to be symmetrical ab initio.

A case can therefore be made out for attempting to unravel the symmetry between the forearm and leg and between the hand and foot on a morphological basis. In order to simplify the comparison, the left arm has been superimposed on the right leg in figure 8. The left arm, being the mirror image of the left leg, must therefore be an exact morphological copy of the right leg, if the basis of comparison is correct.

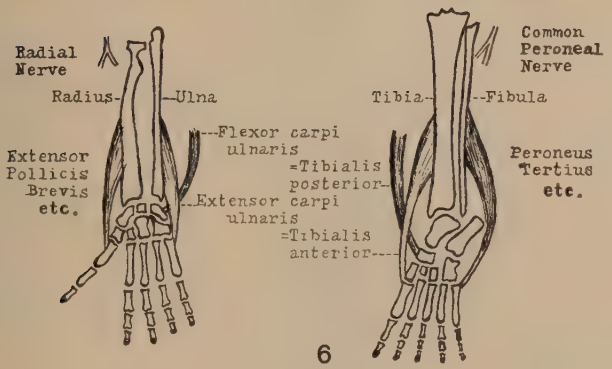
The correspondence between the shoulder and the pelvis and between the brachium and the thigh is again obvious. The olecranon epiphysis corresponds to the patella. The posterior border of the ulna corresponds to the anterior border of the tibia. The extensor carpi ulnaris corresponds to the tibialis anterior. They arise from symmetrically homologous bones, and they have this also in common in their insertions, that they both reach symmetrically homologous bones, the former the fifth metacarpal and the latter the first metatarsal. The extensor quinti digiti proprius, being in any case most probably a member of the deeper stratum of the primitive extensor tendons, is homologous to the deep extensor brevis hallucis. The tendon of the extensor digitorum communis, which goes to the little finger, corresponds to the extensor hallucis longus. The three remaining tendons of the extensor digitorum communis together with the extensor pollicis longus may be homologized with the extensor digitorum longus. The extensor indicis proprius corresponds to the most lateral tendon of the extensor digitorum brevis on the foot. The tendons of this latter muscle which go to the

second and third toes are unrepresented in the hand, unless corresponding short extensors to the medius and annularis digits happen to be present as abnormalities, as is frequently the case. The extensor pollicis brevis and the abductor pollicis longus, which are usually united into one muscle in forms lower than man, can be suitably homologized by the peroneus tertius alone or with the addition of the occasional peroneus quintus. The extensor carpi radialis brevis and the extensor carpi radialis longus are well represented by the peroneus brevis and the peroneus longus, respectively. The crossing of the sole by the peroneus longus tendon is merely another example of the way in which the big toe, being short of muscles of its own, has borrowed from the rich supply of muscles of the little toe. Until the phylogeny of each individual muscle is completely worked out, it is impossible to maintain that the homologies stated are individually correct, but they are sufficiently accurate to show that the little toe with its rich group of peroneal muscles is more comparable to the thumb and the numerous muscles related to it than is the big toe (fig. 6).

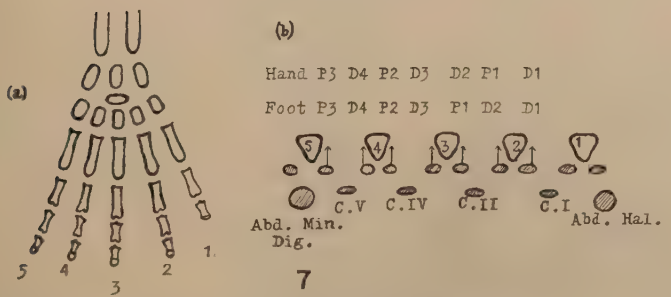
On the flexor aspect of the limbs the flexor carpi ulnaris is homologous to the tibialis posterior. The V-shaped arrangement of muscles formed on each side of the biceps brachii by the brachioradialis laterally and the pronator teres and the flexor carpi radialis medially can be homologized to the lateral and medial heads of the gastrocnemius. The palmaris longus is best represented by the plantaris. The flexor digitorum sublimis is homologous to the soleus together with the flexor digitorum brevis, although the tendon to the thumb has become lost in the arm and the tendon to the big toe in the foot. The flexor digitorum profundus and the flexor pollicis longus together correspond to the flexor digitorum longus, the flexor hallucis longus, and the accessorius. This was originally one continuous sheet in each limb, but it has become broken up differently in each case to serve a different purpose. Morphologically, however, it is easy to compare the most fibular with the most radial tendon, however little the former may be differentiated as compared with the latter.



5



6



7

Fig. 5 Corresponding parts in the left arm and thigh regions.

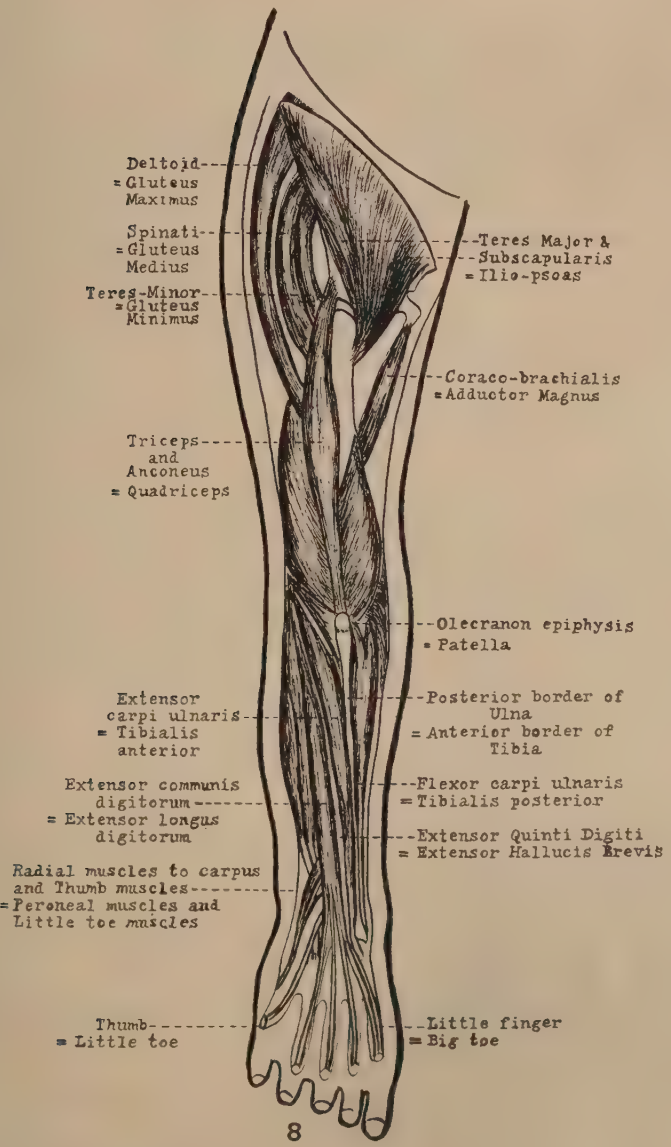
Fig. 6 Corresponding parts in the left hand and foot regions.

Fig. 7 (a) Arrangement of the bones in a primitive unmodified hand or foot. (b) Arrangement of muscles in the hand or foot of an ape. Arrows indicate their position in the human hand and foot. (Modified after Keith.)

The morphology of the hand and foot is a very large subject, but for the present argument a very few facts will suffice. In the most primitive and unmodified types of hand and foot, met with in certain reptiles and amphibians, the various skeletal and muscular elements are alike in number and arrangement in each case. Figure 7 (a) represents such a hand or foot, and it is equally noteworthy that in each of such hands and feet there is very little specialization of the pollex and hallux. Each manus and pes is practically symmetrical round its central digit, so that in such forms the thumb is readily comparable to the little toe.

Moreover, Keith(6) has shown that the muscles of the hand and foot of the ape are arranged identically (fig. 7 (b)). The arrows show that the muscles have migrated in a similar manner to form the human hand and foot, and that it is only a slight difference in the form of the muscle and a change of name which constitutes the difference between the hand and the foot. A glance at this figure and similar reasoning will show how it is possible for one to maintain that the muscles on the lateral side of the hand are homologous to those on the lateral side of the foot in spite of their apparent difference in form, for they are morphologically identical in arrangement.

The reduction in number of the phalanges of the pollex and hallux and the anomalous ossification of the first metacarpal and the first metatarsal bones do not present any insuperable difficulty to the theory of symmetrical homology. Abnormal human thumbs with three phalanges and little toes with only two are sufficiently common abnormalities to show that the thumb is an ordinary and an unstable digit and that reduction in the number of the phalanges can readily take place. McGregor(7), in a recent paper on the morphology of the thumb, has come to the conclusion that the anomalous ossification of the first metacarpal and of the first metatarsal is a functional adaptation and can be adequately explained on mechanical grounds.



8

Fig. 8 Diagram showing how the muscles of the left arm correspond exactly to those of the right leg.

As regards the bones of the foot, therefore, we must homologize the navicular with the calcaneus, the lunate with the talus, the triquetrum with the navicular, the greater multangular with the cuboid, the lesser multangular with the third cuneiform, the capitate with the second cuneiform, and the hamate with the first cuneiform, while the first, second, third, fourth, and fifth metacarpal bones and accompanying phalanges must correspond to the fifth, fourth, third, second, and first metatarsal bones and accompanying phalanges, respectively.

Arteries are regarded as too variable morphologically to be of much value as standards of comparison. According to the serial homologists, the brachial artery is homologous to the inferior gluteal artery, the ulnar is represented by the posterior tibial artery, and the radial by the internal saphenous artery. On a symmetrical interpretation the brachial artery becomes readily comparable with the femoral and its continuation the popliteal artery. The ulnar corresponds to the posterior tibial artery, the radial artery to the peroneal, and the posterior interosseous artery to the anterior tibial artery. Altogether, the comparison on the symmetrical basis is much more harmonious than on the serial hypothesis.

As regards using the spinal nerves as keys to homologies or as standards of comparison, it is only necessary to point out how they have failed as such in the serial comparison. Homologous fibers take a totally different course in the two limbs. The segmental distribution of the cutaneous nerves is as favorable to a symmetrical as to a serial view of the morphology of the limbs; according to the former view, apomphalic areas in one limb correspond to apomphalic areas in the other limb, whereas the latter view makes preaxial areas in one limb correspond to preaxial areas in the other limb.

In the case of the motor nerves, Geddes(5) adduces experimental evidence in support of the law "that of two limb muscles that which is the more superficial is usually supplied

by a nerve apomphalic to that which supplies the deeper muscle.'' The usual statement in the text-books, that the fifth cervical nerve supplies the abductors and the lateral rotators of the arm, and the flexors and the supinators of the forearm, that the sixth cervical nerve supplies the opponents of these, that the seventh cervical nerve supplies the flexors and the extensors of the wrist, that the eighth cervical nerve supplies the flexors and extensors of the fingers, and that the first thoracic nerve supplies all the short muscles of the hand, would seem to indicate that the craniocaudal series of nerves find their expression on the limb morphology not in any preaxial and postaxial modification, but on the very characteristic proximodistal segmentation of each limb.

SUMMARY

1. There is no evidence of a general serial modification of the arm and leg, such as is usually described as being present. The cephalization of the thumb and big toe is probably a secondary modification of a functional character, which is not universally present in all forms and which does not dominate the general morphology of the rest of the limbs, as it is usually supposed to do.

2. On the other hand, there are many facts which support the view that the limbs have been modified according to a craniocaudal or biterminal symmetrical plan. This may also be part of the fundamental plan of organization of the limbs, and in any case it must always be taken into consideration in making any comparison between them.

3. The segmental homology between the proximodistal segments of the arm and leg is the most definite existing homology, and it is suggested tentatively that this proximodistal segmentation, and not any preaxial and postaxial modification, is the expression of the genetic relationship of the limbs possibly to a series of somites and certainly to a series of segmental nerves.

4. The arm and leg thus present a segmental homology, but the elements in each segment are mirror images of each

other, so that there is also a symmetrical homology. This symmetry is blurred distally by the cephalization of the hand and foot to form the thumb and big toe—an example of heterogeneous homoplasy.

LITERATURE CITED

1 Flower 1876 An introduction to the osteology of the Mammalia. Macmillan & Co., London.
2 Huxley 1871 The anatomy of vertebrate animals. J. and A. Churchill, London.
3 Humphrey 1858 Treatise on the human skeleton. London.
4 Parsons 1908 Journ. Anat. and Physiol., vol. 42.
5 Geddes 1912 Journ. Anat. and Physiol., vol. 46
6 Keith 1913 Human embryology and morphology. Arnold, London.
7 McGregor 1926 Journ. Anat. and Physiol., vol. 60.

THE SUPPOSED HOMOLOGY OF VENA AZYGOS AND VENA CAVA INFERIOR CONSIDERED IN THE LIGHT OF NEW FACTS CONCERNING THEIR DEVELOPMENT

FRANKLIN P. REAGAN
Department of Anatomy, Indiana University

Existing opinions concerning the development of postrenal vena cava in placental mammals have this in common: that the vein referred to is, for the most part, considered to be a serial homologue of the azygos vein. These opinions fall generally into two groups and are classifiable on the basis of propositions as to whether postrenal vena cava is or is not a transformed posterior cardinal vein.

At the risk of causing a thoroughly familiar literature again to be reviewed, it may be stated that the observations of Hochstetter ('93), Lewis, ('02), and Begg ('17), would indicate that postrenal vena cava may be a posterior cardinal derivative. Until recent times, this view was widely accepted. According to Huntington and McClure ('07), Sabin ('15), and McClure and Butler ('25), the vessel is largely a homologue of the greater part (Huntington, McClure, Butler), or of the entirety of the azygos vein; it is said to be formed from no part of the posterior cardinal, but from a new vessel corresponding serially to the main part (Huntington, McClure, Butler) or the entirety of the azygos vein (Sabin). It is the purpose of the present account to outline a series of reasons for believing that the foregoing alternatives do not exhaust the possibilities or even include the most logical of the probabilities.

Before considering the general question of homology of these vessels, we may profitably review some recently dis-

covered facts concerning the azygos itself, on the basis of which it is possible to discuss the homologies of that vessel.

The investigations of Parker and Tozier ('97), McClure ('06), Kampmeier ('12), Reagan ('19), L. H. Strong ('25), and Martha Thompson Strong ('25), all indicate that at least a small cranial portion of functional azygos may be a remains of the posterior cardinal vein. All these observers are agreed that, caudal to this portion, the main part of the functional azygos line is derived independently of the posterior cardinal vein. The plexiform forerunner of the main part of azygos has been designated as 'supracardinal vein' (Huntington and McClure) and as 'prevertebral plexus' (Sabin).

By Hochstetter ('93) it had been noted, and other authors had shown that, whereas the main part of azygos ordinarily lies ventrolateral to the dorsal aortic rami, it may, in some cases, even in the caudal thoracic region, lie medial to these aortic rami. To the part which behaved in this manner, Hochstetter applied the term 'new formation.' It remained for the work of L. H. Strong to show that in the rabbit the 'new formation' arises from a plexus dorsal to the aorta and extending at least from the cervical to the sacral region; that the longitudinal vessels arising from it differ from typical forerunners of azygos as much as the latter differ from posterior cardinals. Throughout the thorax he found on each side in the rabbit a small longitudinal vessel just medial to the bases of the dorsal aortic rami. On the right side of the thorax of the rabbit the vessel persists in the three caudal segments. Elsewhere in the thorax these longitudinal vessels disappear. He found that in the lumbar region the derivatives of the dorsal, median plexus link the intersegmental drainages of the two sides. His work may be regarded as having filled in one of the last great deficiencies in our knowledge of azygos development. It cleared up the confusion in Sabin's interpretation of Hochstetter's findings. Any complete history of intersegmental drainage must take into account the facts in the valuable work of L. H. Strong.

An important observation was that of Parker and Tozier ('97) and also of Sabin ('15), who described the azygos line as arising from a plexus independent of the posterior cardinal vein; in this work it was shown that the azygos is not formed as a series of longitudinal fusions between adjacent intersegmental tributaries to the posterior cardinal vein. The latter observation is of interest in any consideration of vena-caval homology.

In 1923, I was permitted by the American Association of Anatomists to report before their meeting certain facts concerning azygos development not recorded in the proceedings of that meeting. Among these was the fact that, before the time of appearance of a distinct longitudinal azygos (supracardinal or prevertebral) line, transverse vascular connections can be found between the bases of the dorsal aortic intersegmental arteries and the bases of the corresponding intersegmental tributaries to the posterior cardinal vein; that the azygos appears as enlargements of the fine longitudinal connections between these transverse anastomoses. At that time it was also shown that the cranial end of azygos line has an early direct arterial supply from the right dorsal aorta at a point near the union of the latter with the left aorta.

The essential characteristics of typical azygos lines are these: they occupy positions ventromedial to the sympathetic trunks (Reagan, '19, pp. 116, 117); their special intersegmental tributaries, where present, drain dorsomedially with reference to the sympathetic trunk; the venous lines and their typical permanent tributaries lie ventrolateral to the dorsal aortic rami; the azygos vessel, lying medial as it does to the sympathetic trunk, lies medial to the strands of nerve tissue (lines of migrating neuroblasts or lines of nerve fibers) coursing between the sympathetic ganglia and the ganglionic masses ventrolateral to the aorta (i.e., the azygos lines are medial to the periaortic sympathetic plexus). The characteristics just enumerated do not apply to the posterior cardinal part of azygos nor to the part lying medial to the dorsal aortic rami.

With a hope that something ultimately constructive may come of it, I wish to point out certain features of the work of those who believe that postrenal vena cava is a counterpart of the main part of azygos vein. We may consider first the work of McClure and Butler, for the reason that they give figures which represent undiagrammatically their wax reconstructions. Their figures lend themselves to more complete analysis than do the diagrammatic but highly instructive figures of Huntington and McClure ('20), or the beautiful but incomplete series of figures of Sabin ('15). The work of F. T. Lewis was magnificently executed within a series of stages not late enough to show clearly the reconstructible beginnings of postrenal vena cava. In offering criticism of these observations, I am not unmindful of the difficulties faced by those who pioneer a subject as compared with the difficulties of those who follow them. However much these considerations deserve to be subordinated to those of ultimate truth itself, they need not be regarded as having been ignored in the present account.

In figure 11 of McClure and Butler ('25, p. 357) there is shown a thoracic azygos line of definitely double nature. One part ends abruptly. The other is continued caudally, but is connected with an almost transverse vessel which, in turn, is connected with postrenal vena cava. The latter is labeled *pars supracardinalis*. It is interpreted as the serial homologue of thoracic azygos and is described as being 'morphologically inseparable' from that vessel, though in several stages where both exist they are not shown to be connected. In the same figure there is continued in a direct line caudally from the thoracic azygos an unlabeled plexus which may possibly represent a vessel which I would interpret as a true lumbar homologue of thoracic azygos (i.e., of the part previously defined as 'typical azygos'). Reexamination of the specimen from which the figure referred to is made (Harvard Embryological Coll., no. 2051) should show that the postrenal vessel 'pars supracardinalis' (postrenal vena cava) lies lateral to the periaortic sympathetic plexus, and therefore not

medial to the sympathetic trunk. But the thoracic 'supracardinal' lies medial to the sympathetic trunk if it is a vessel which could have ever become an azygos. The unlabeled lumbar plexus in the figure under discussion probably resembles the more medial vessel labeled 'thoracic supracardinal' in lying ventromedial to the sympathetic trunk, ventrolateral to the dorsal aortic rami, and in having tributaries which drain dorsomedial to the sympathetic trunk. Since the postrenal vena cava of the figure drains the unlabeled plexus, it indirectly drains its tributaries.

In the adult the postrenal vena cava receives its intersegmental drainage largely from vessels medial to the sympathetic trunks. The earliest tributaries of postrenal vena cava are lateral to the sympathetic trunks. This change of drainage results from the degeneration of the earliest tributaries, and from the transverse tapping of the dorsally located, unlabeled lumbar plexus (McClure and Butler, fig. 11, ibid.). What I have suggested to be the lumbar homologue of thoracic azygos further resembles the latter by taking care of intersegmental drainage abandoned by posterior cardinal intersegmental veins. In the lumbar region the lumbar homologue of azygos usurps this function only after the function has been temporarily usurped and then abandoned by postrenal vena cava. But, as we shall see, the azygos line in the caudal half of the thorax takes up the function of intersegmental drainage (previously performed by posterior cardinal) only after that function has been temporarily performed by a thoracic vessel having cross-sectional relationships similar to those of postrenal vena cava.

The most caudal segment of adult azygos is obviously a transverse structure.

The left homologue of the unlabeled dorsally located venous plexus in figure 11 of McClure and Butler ('25) is probably shown, but is likewise unlabeled in their figures 13, 15, and 16. It can be seen dorsal to the left inferior vena cava, which is itself labeled 'pars supracardinalis.' The right dorsal plexus cannot be seen in figures 13 and 15 (ibid.).

In figure 16 of McClure and Butler ('25, p. 373) there are shown conditions in an abnormal human embryo (Harvard Embryological Coll., no. 2128) of 45 mm. Caudal to the renal anastomosis the functional vena cava is a left one. The left sex vein is normal. The right sex vein joins the renal anastomosis—an abnormal condition which need not have occurred if the postrenal vessel labeled *Sprc. Dext.* had been a diminutive vena cava. But the vessel *Sprc. Dext.* is so interpreted. This interpretation seems quite unwarranted. If we were to seek the true left homologue of *Sprc. Dext.* (postrenal part) in this figure, we should probably find that homologue not to be the functional left postrenal vena cava (labeled *Sprc. Sin., P. Sprc.*), but rather we should find it to be the smaller unlabeled vessel dorsomedial to the latter. By dotted lines this small dorsal unlabeled sinistral vessel is connected with the prerenal *Sprc. Sin.* (typical hemiazygos line) just as the small dextral postrenal vessel (so-called diminutive vena cava) is connected with the right prerenal *Sprc. Dext.* (typical azygos line). Inferiorly, the small unlabeled left dorsal postrenal vessel is cut off more abruptly in the figure than it probably is in the specimen. In all probability, the postrenal *Sprc. Dext.* and the left unlabeled dorsal postrenal vessel, then, are the respective serial homologues of the main parts of thoracic azygos and hemiazygos veins, and are comparable to the unlabeled dorsal postrenal vessels already referred to in figures 15, 13, and 11 of McClure and Butler ('25).

At the 45-mm. stage (fig. 16, McClure and Butler, ibid.) in man, the postrenal homologues of azygos and hemiazygos have probably lost their own direct intersegmental tributaries which were situated ventral to the dorsal aortic rami. Complete reconstruction of the drainages would probably show that the left unlabeled dorsal postrenal vessel drains the dorsomedian vessel (*Sprc. X*), which now has its own direct intersegmental tributaries lying dorsal to the dorsal aortic rami. It is probable that the postrenal *Sprc. Dext.* of the figure lies medial to the right sympathetic trunk. The

unlabeled left dorsal postrenal vessel of the figure probably occupies a position comparable to this on the left side. The unlabeled left dorsal postrenal vessel of the figure is obviously not a diminutive vena cava. The postrenal *Sprc. Dext.* is very probably not. The functional (left) postrenal vena cava of the figure should not be found to be medial to the sympathetic trunk of the left side, but lateral to the left part of the periaortic sympathetic plexus, and therefore morphologically lateral to the left sympathetic trunk. If the postrenal *Sprc. Dext.* of the figure (McClure and Butler, fig. 16, ibid.) were a diminutive vena cava, it should lie lateral to the right portion of the periaortic sympathetic plexus. It probably does not do this.

The right postrenal vena cava of the abnormal embryo referred to (fig. 16, McClure and Butler) has probably disappeared. Normally, there is no trace of a left inferior vena cava in man at this stage, whereas postrenal homologues of azygos and hemiazygos persist until stages considerably later than this. To summarize the conditions of intersegmental drainage in this specimen: the left postrenal vena cava drains the postrenal dorsal unlabeled vessel (lumbar homologue of typical hemiazygos); the latter vessel drains the dorsomedian vessel (*Sprc. X*); this drains its own tributaries lying medial to the dorsal aortic rami, and, in addition, it drains the postrenal *Sprc. Dext.,* which would later have completely disappeared.

The history of the probable representative (in the rabbit) of this thoracic portion of the *Sprc. X* (McClure and Butler, '25, fig. 16) has been worked out under my direction by L. H. Strong ('25). In an account by him now in press ('26), he states that the probable lumbar homologue of this dorsomedian, practically uninterpreted vessel (*Sprc. X* of McClure and Butler) links the intersegmental drainages of the two sides so that they enter the vena cava together. He suggests that the lumbar continuation of the *Sprc. X* of this figure represents the postrenal continuation of that caudal part of azygos lying dorsal to the dorsal aortic rami in the rabbit.

Human material is necessary for the proof of this probably correct assumption.

The dorsal aortic plexus (L. H. Strong, '26) has derivatives of two sorts—transverse and longitudinal. In the thorax the transverse elements serve to unite the intercostal veins of the two sides, especially in forms where there is only one functional azygos line. In the thorax this linkage is effected more simply than it is in the lumbar region; it is effected largely by the persistence of portions of the plexus lying dorsal to the aorta and situated between the bases of typical azygos tributaries (p. 131). In the thorax the longitudinal derivatives of the plexus are not of great prominence, except where they form parts of the composite azygos line. In man, in the entire lumbar region the longitudinal element of the dorsal aortic plexus is present until relatively late in development as a prominent continuous dorsomedian element just ventral to the vertebral centra. Prof. Arthur Robinson has suggested for this vessel in man the term: subcentral vein (vena subcentralis, pars lumbalis). As I can state from direct observation, this vessel receives directly the late intersegmental drainage of the lumbar region in man. In some forms other than man, it has so far been impossible to demonstrate a continuous longitudinal subcentral vein. In these cases it seems possible that the linkage of lumbar veins is developed out of transverse elements of the dorsal aortic plexus. Whether the linkages are originally transverse or whether they are intermittent remains of an originally longitudinal vessel, the end results are the same.

In any event, the lumbar intersegmental veins are derived centrally from the dorsal aortic plexus and its own special tributaries lying dorsal to the dorsal aortic rami. They are new structures, except peripherally, where they are remains of the original spinal tributaries to the posterior cardinal. The central portions of the lumbar veins are not comparable to like regions of typical azygos tributaries. I am not aware that this observation has previously been made.

In man the lumbar subcentral vein, and normally the right postrenal lumbar homologue of azygos, both longitudinal vessels, degenerate except where small remnants of the former persist locally to link the peripheral tributaries of the former subcentral vein and where small remnants of the latter (i.e., of postrenal homologue of azygos) persist to connect the remnants of subcentral vein with postrenal vena cava.

In the early embryo the peripheral part of the spinal tributary to posterior cardinal drains neural and vertebral tissue of such relatively great expanse that the spinal vessel has an almost dorsoventral direction. The flow of blood in it is ventral and lateral. The regions of the body containing posterior cardinal veins on the respective two sides become widely separated, owing to the enormous growth of the intervening tissues. The neural and vertebral tissues remain conservative as regards growth. There is a marked tendency toward the centralization of drainage. The more lateral transverse paths of drainage are rejected for the more medial ones. The importance of this factor in the degeneration of the more lateral longitudinal vessels has generally been overlooked. Posterior cardinal, except as sex vein, persists only in those parts of its extent in which it lies close to the median plane, near the duct of Cuvier, and in the most caudal lumbar segment of some mammals, where on the right it may retain its original spinal tributary which courses lateral to the sympathetic trunk, and therefore does not enter vena cava with the corresponding left vein.

The principal object of the ensemble of foregoing remarks has been to show, from material described and figured by previous authors themselves, that the non-posterior-cardinal parts of azygos and of hemiazygos veins have lumbar homologues which are either absent from the figures and descriptions by those authors, or are misinterpreted; that these lumbar homologues of azygos do not enter into the formation of inferior vena cava; that their rôle in intersegmental drainage has been totally overlooked. We may now consider another view hitherto unexpressed: that the main part

of postrenal vena cava has a representative in the caudal half of the thorax and in the cranial part of the lumbar region which does not enter into the formation of the azygos veins. This hitherto misinterpreted or unnoticed structure may conveniently be called the thoracolumbar drainage or vein. It occurs on each side as a temporary vessel of considerable functional importance.

Postrenal vena cava is a composite structure. Only with a certain amount of reservation should one speak of any vessel as its serial homologue. In point of relationship with nervous structures and nature of function in the history of intersegmental drainage, the longitudinal part of the postrenal vena cava and thoracolumbar vein are very similar. Where they first join the transverse element of postrenal vena cava (subcardinosupracardinal anastomosis of Huntington and McClure) they are in perfect linear continuity. The main part of each is formed out of the same continuous plexus. By 'postrenal vena cava' that part of inferior vena cava caudal to the renal veins and exclusive of its caudalmost segment is referred to.

The thoracolumbar drainage has no adult derivative. It is distinctly lateral to the elements of the sympathetic system, medial position with reference to which defines a correct interpretation of azygos veins. It lies parallel to, and temporarily coexists with azygos forerunners in the caudal half of the thorax. It is a makeshift drainage which serves in anticipation of, and during the process of, posterior cardinal degeneration in the caudal half of the thorax. It serves to take care of intersegmental drainage which is being abandoned or which has been abandoned by the ventral ends of the intersegmental tributaries to the posterior cardinal. The thoracolumbar line serves to transport this drainage caudally into the inferior vena cava pending the establishment of an azygos line in the so-called supracardinal or prevertebral plexus. As soon as the azygos lines have formed, they usurp the function of the thoracolumbar lines and conduct the intersegmental drainage again cranially. The thoracolumbar

drainages have numerous transverse connections with the early azygos plexus; the latter has an abundant direct arterial supply. Thus the thoracolumbar drainage is a factor in initiating the growth of the azygos line, only to be replaced by the latter. The functional necessity of the thoracolumbar drainage is involved in the degeneration of the posterior cardinal vein. The dynamics of this degeneration are given most admirably by F. T. Lewis ('02, p. 234).

The thoracolumbar drainage has not escaped the attention of certain previous observers. But in all cases where it has been observed it has either been neglected in description or confused with some other venous structure. It has never been designated by any name which would distinguish it from the structures with which it has been confused.

Thoracolumbar drainage is probably represented in the vessel '*r*' in figures 20, 21, 22, and 25, Tafel 22, Hochstetter ('93). It is called cranial portion of the caudal segment of posterior cardinal.

It is probable that thoracolumbar drainage was considered by F. T. Lewis to be a part of posterior cardinal vein. In a cross-section figured by him ('02, p. 235), a vessel dorsal to the mesonephric artery and well removed from the wolffian body is called posterior cardinal. Similar section of an embryo slightly younger would show that the posterior cardinal lies dorsomedially, well within the matrix of the wolffian body. Intervening stages would fail to show a migration of the posterior cardinal away from this position, but rather they would show its degeneration in loco. Removal of the wolffian body involves the removal of the posterior cardinal at this level if it still exists.

In figures 5 and 6, plates 1 and 2, of Lewis ('02), it will be seen that the 'anterior divisions' of posterior cardinals have been reconstructed as far caudally as the apparent level of the cranial ends of the wolffian bodies. Here they stop very abruptly. Near this may be seen the extremely slender termini of vessels draining caudally. These vessels are called posterior divisions of posterior cardinals. Thoracolumbar

drainages are probably represented in the slender, caudally draining, cranially located portions of vessels designated in these figures as posterior divisions of the posterior cardinals. Reexamination of the specimen might show a continuation of 'anterior division of posterior cardinal' far into the wolffian body as a degenerating structure, and lying well dorsolateral to the cranial portion of the 'posterior cardinal' in the figures just referred to.

It might be suggested as entirely possible that this same thoracolumbar drainage is represented in figure 7 of McClure and Butler ('25, p. 348). In this figure is a vessel directly continued cranially from the lumbar vessels 'B' and 'C' labeled *Sprc.* in their postrenal region. This cranial extension beyond *Anast. Subc. Sprc.* is described as extending cranially to the level of the cranial border of the 'intersubcardinal anastomosis.' Its anastomoses with the posterior cardinal are called 'posterior cardinal-supracardinal anastomoses.' One gets the impression that the vessel will later become continuous with the vessel labeled *Sprc.* (*Az.*), and that at least the caudal part of the azygos, if it exists in this region, should be formed from it. On page 350 of McClure and Butler ('25) it is stated that azygos and 'lumbar supracardinal' are not continuous "as they are at a later stage." Their series of later stages do not invariably show the structures continuous, especially their figure 17; this is a diagram to illustrate the adult, where the right remnant of 'supracardinal' just cranial of postrenal vena cava receives the queried interpretation of lumbar vein. The figure represents very inadequately the adult condition. In this figure no provision is made for that part of the azygos vein which text-books of human anatomy usually picture and describe as entering the postrenal vena cava. A late stage in the degeneration of the thoracolumbar line might give an appearance somewhat similar to that referred to in figure 17 of McClure and Butler. Reexamination of the specimen from which figures 7 and 8 of McClure and Butler were made would probably show that the vessel called 'supracardinal' near the level of the 'inter-

subcardinal anastomosis' lies lateral to the periaortic sympathetic plexus and therefore not medial to the sympathetic trunk. If this be so, it could never be a part of the azygos line, nor could it be a lumbar vein. It is not a part of vena cava. These exhaust the possibilities of 'supracardinal' derivation in the region, so far as I can discover them in the account under consideration.

In the specimen from which figures 7 and 8 of McClure and Butler ('25) were made, the thoracic posterior cardinals exhibit few signs of degeneration. Whenever these vessels are as strongly functional as they are in this specimen, the actual forerunners of azygos veins (as we know them in the adult) are not sufficiently developed in the caudal thoracic and cranial lumbar regions to be readily reconstructible in wax. This is especially true if sections are thick and preservation is imperfect; this may conceivably have been true of this specimen. At the onset of posterior cardinal degeneration in the caudal thoracic region, thoracolumbar drainage develops as a functional substitute for posterior cardinal vein considerably sooner than reconstructible forerunners of azygos lines are developed at these levels. The vessel continued cranially from postrenal vena cava and described as a part of the 'supracardinal line' is probably the thoracolumbar drainage. Instead of draining the posterior cardinal directly, as shown in figure 7 of McClure and Butler, it probably drains the intersegmental tributaries to that vessel. The 15-mm. embryo from which figures 10 and 11 of McClure and Butler were made has sufficiently degenerate posterior cardinals, and is well enough preserved that it should be possible to find thoracolumbar and azygos lines paralleling each other. It is probably not without significance that the thoracic 'supracardinal' of these figures is shown to be double. In figure 11 (ibid.), the more medial of the 'supracardinal' thoracic vessels communicates with postrenal vena cava. In figure 10 (ibid.) neither of them does. This renders difficult an analysis of these figures. In figure 13 (ibid.) the vessels labeled thoracic 'supracardinal' have the appearance of true azygos

lines. But the specimen is not old enough for the thoracolumbar lines to have degenerated. In figure 15 of McClure and Butler ('25) there projects cranially from the right side of the 'renal collar' a blunt, unlabeled structure. It may conceivably lie medial to the sympathetic trunk. The most caudal portion of the 'supracardinal' which enters the right cranial surface of the 'renal collar' might conceivably be found to be lateral to the periaortic sympathetic plexus. If this were so, the thoracolumbar drainage could erroneously have been shown as a supposed caudal continuation of the azygos line. In this stage of human development the connection of thoracic azygos with its lumbar homologue (the blunt projection just referred to) is often disturbed by the developing medial crus of the diaphragm. Strong transverse connections are developed between the azygos and thoracolumbar line, so that the latter in its caudal region becomes an important collateral drainage to receive the contents of peripheral intersegmental veins. It so continues as a prominent structure lateral to the periaortic sympathetic plexus until the (human) embryo is about 40 mm. long. By that time the azygos lines medial to the sympathetic trunk have begun to strengthen their connections with the lumbar homologues of azygos. By the time the embryo has reached the length of 45 mm., the thoracolumbar collateral drainage has disappeared and continuous azygos lines lie medial to the sympathetic trunks, as they probably do in figure 16 of McClure and Butler.

If the thoracolumbar vein was seen at all by Huntington and McClure in the cat ('20), their figures do not show it.

The thoracolumbar drainage was apparently regarded as merely an anomaly by Sabin ('15). Sabin regarded the 'prevertebral' (equivalent of 'supracardinal' system of Huntington and McClure) plexus as very simple in the thorax, and described it as a structure lying entirely dorsal to the aorta, or practically so. The conditions in Sabin's figure 10 are described as typical for the thorax.

In the abdominal region the 'prevertebral plexus' is described by Sabin (p. 26, ibid.) as 'excessively complex,' consisting of one part which "fills the entire region between the aorta and the vertebrae" and also "another which fills the entire region between the aorta and the Wolffian bodies." The latter part was described as the lateral sheet of the 'prevertebral plexus' and from it postrenally vena cava was said to develop.

It is apparent that Sabin did not realize the great importance of a 'lateral sheet' of the plexus in the thorax or the great importance of the 'mesial sheet' in the lumbar region.

The one specimen in which Sabin probably had the best opportunity of interpreting the beginnings of a thoracolumbar drainage was that from which figure 11 (Sabin, '15) was made. What is a highly significant condition was interpreted as anomalous. On page 24 (ibid.) the intersegmental drainage is described as follows: "it will be noted that in figure 11 the eighth and ninth run to the level of the tenth where this common stem enters the Wolffian body. . . . This is simply an anomaly of this particular specimen and is without special significance." The thoracolumbar drainage is undoubtedly present but uninterpreted in Sabin's figure 12.

Sabin's figures 13 and 18 are the only ones in which we are to judge the caudal extent of the lumbar homologues of azygos lines. In neither of these are we able to derive as adequate a notion of lumbar homologues of azygos as we are from the various unlabeled dorsally located lumbar plexuses in the figures by McClure and Butler. Their rôle in intersegmental drainage is neglected.

On page 27 ('15) Sabin makes this point: that Hochstetter shows in one specimen (fig. 19, Tafel 22, '93) an inferior vena cava medial to the kidney and a posterior cardinal lateral to it; that his observations are essentially the same as the observations of those who claim that vena cava is not derived from posterior cardinal; that the two views are "merely interpretations of the same observation." One might, indeed, take certain figures by Hochstetter, change the labels, substituting

'subcardinal' for 'suprarenal,' etc., and produce figures illustrating the discoveries with which Sabin credits F. T. Lewis. These things are due to the fact that both Hochstetter and Lewis saw well and drew well, and embryonic material is surprisingly constant in its make-up. The inadequacy of Hochstetter's account lies largely in its terminology. The term 'posterior cardinal' is certainly inadequate to describe all the structures to which Hochstetter applied it. Lewis made a real advance when he gave us a term to distinguish adrenal veins from posterior cardinals. Huntington and McClure made a real advance when they gave us a term to distinguish forerunners of azygos and vena cava from posterior cardinal. Sabin gave us a synonym for the term they coined. L. H. Strong made a real advance when he showed that the 'new formation' which Hochstetter had observed in the azygos vein of the rabbit is not a homologue of the part of the azygos vessel cranial to itself, but that it is from a separate plexus, and hence deserves a separate name.

It is hoped that even further advances in terminology may be permitted. Should any author resist further attempts at analysis, classification, and explicit terminology for the 'excessively complex' supracardinal system or prevertebral plexus, he would be resisting that very sort of progress which has hitherto made description gradually more exact.

The description of the development of inferior vena cava in the cat, by Huntington and McClure ('20) has been of great service in the interpretation of the vessel in other forms, and especially in the interpretation of anomalous conditions of it. Their investigations are based on comparative studies more extensive than those of any other investigations on the subject. For this reason it is with some lack of assurance that I would point out certain features of their work. In the oldest stages of cat figured by them and in their descriptions one gets the impression that the vena cava is formed by the intermittent fusion of two venous (supracardinal) lines, each lying lateral to the median plane and, by inference, lateral to the dorsal aortic rami. If this were so,

the postrenal vena cava should, in the adult cat, be pierced intermittently by these dorsal aortic rami. If it is not, then its history is incomplete in the account of Huntington and McClure, especially with reference to the left side.

In embryonic and foetal Carnivora the extreme ventral position of the dorsal aorta, the relatively close approximation of the sympathetic trunks, the relatively close approximation of the forerunners of (functional) right and (non-functional) left venae cavae to the median plane and their far-dorsal position, the somewhat undeveloped condition of lumbar homologues of azygos lines, the extreme suppression of a lumbar subcentral vein, the fusion of the dorsal aortic rami—all these things conspire in the carnivor to give to the developing venae cavae a superficial resemblance to the developing azygos lines, as seen in a typical cross-section of the thorax of the embryonic carnivor. Despite these unusual conditions in the embryos of Carnivora, their body-wall veins can be brought into line with the proper interpretation of the vessels in other placental mammals if the only safe landmarks, the sympathetic nervous elements, be not ignored.

Apropos of the importance of the sympathetic trunks as landmarks with reference to which to establish homology, I wish to state that, whereas, in 1919 (p. 116), I stressed the importance of the fact that the azygos lines lie medial to the sympathetic trunks, I erroneously followed the current usage of describing superior intercostal veins as derivatives of the general azygos complex, though my descriptions and figures show superior intercostals of the pig to be lateral to the sympathetic trunks. This erroneous usage might have led to confusion, had any subsequent observers taken notice of my statements concerning the topographical importance of nerve trunks. For lower mammals such usage is entirely misleading. In man the highest intercostals, at least, correspond to the superior intercostals of lower mammals in having a position lateral to the sympathetic trunks and in their manner of formation as fusions between adjacent intersegmental veins. They are, therefore, not derivatives of any plexus to which

the term 'supracardinal' or any synonym for that term can be applied.

Incidentally, it might be stated that the right suprarenal vein is a transverse structure, a tributary to the right mesial cardinal, but not a derivative of the vein itself.

The material for a preliminary study by which the essential facts of the foregoing remarks were arrived at consists of that prepared by the writer during a period of six years, and also of the material in the embryological collection of the University of Edinburgh. Prof. Arthur Robinson, of the University of Edinburgh, and Dr. Margaret Tribe, of King's College, London, have consented to enter into a collaborative program. More complete accounts, jointly prepared, will later appear upon the subject of vena cava. It is with the consent of these collaborators that I publish my interpretations of previous literature and certain facts arrived at prior to a collaborative program of work.

The present account is submitted with a hope that much work now in progress upon vena cava may be affected by whatever good there is in it. I have recently been consulted with regard to a number of manuscripts of articles dealing with development of, or anomalies of, the vena cava. In these, vena cava (postrenal region) was invariably regarded as a serial homologue of vena azygos. It is hoped that contact with yet another point of view may at least be harmlessly stimulating.

In conclusion, for many kindnesses I wish to thank Profs. C. F. W. McClure, G. Elliot Smith, and Sir Arthur Keith. For the courtesies of their laboratories I wish to thank Profs. Arthur Robinson, James P. Hill, and F. Hochstetter.

Work in progress upon ferret embryos, in collaboration with Professor Robinson, was aided by a grant from the Bache Fund of the (American) National Academy of Sciences. I am gratefully recipient of a Fellowship for study in London and Edinburgh, granted by the John Simon Guggenheim Memorial Foundation.

LITERATURE CITED

BEGG, A. 1917 Posterior cardinal derivatives in the rat. Anat. Rec., vol. 13, no. 1.

FRAZER, J. E. S. 1924 The development of the main veins of the trunk caudal to the duct of Cuvier. Proc. Anat. Society of Gr. Britain and Ireland. Cambridge Univ. Press (1921–1925), p. 99.

———— 1925 The formation of the left common iliac vein. Proc. Anat. Society of Gr. Britain and Ireland. Journ. of Anatomy, vol. 60, pt. 4, p. 485.

HOCHSTETTER, F. 1893 Beiträge zur Entwickelung des Venensystems der Amnioten. III. Säuger. Morph. Jahrb., 20. Bd., 4. Heft, S. 543–648.

HUNTINGTON, G. S., AND MCCLURE, C. F. W. 1907 Development of the postcava and tributaries in the domestic cat. Anat. Rec., vol. 6, no. 3, pp. 29–33.

———— 1907 Interpretation of anomalies of the postcava and tributaries, of the adult cat, based on their development. Anat. Rec., vol. 6, no. 3, pp. 33–36.

———— 1920 The development of the veins in the domestic cat (Felis domestica), with especial reference to the share taken by the supracardinal veins in the development of the postcava and azygos veins, and to the interpretation of variant conditions of the postcava and its tributaries in the adult. Anat. Rec., vol. 20, no. 1, pp. 1–30.

KAMPMEIER, O. F. 1912 The development of the thoracic duct in the pig. Am. Jour. Anat., vol. 13, no. 4, pp. 401–464.

LEWIS, F. T. 1902 The development of the vena cava inferior. Am. Jour. Anat., vol. 1, no. 3, pp. 229–244.

MCCLURE, C. F. W. 1903 A contribution to the anatomy and development of the venous system of Didelphys marsupialis (L.). Part I. Anatomy. Am. Jour. Anat., vol. 2, no. 3, pp. 371–404.

———— 1906 A contribution to the anatomy and development of the venous system of Didelphys marsupialis (L.). Part II. Development. Am. Jour. Anat., vol. 5, no. 3, pp. 163–226.

MCCLURE, C. F. W., AND BUTLER, E. G. 1925 The development of the vena cava inferior in man. Am. Jour. Anat., vol. 35, no. 3, pp. 331–383.

PARKER, G. H., AND TOZIER, C. H. 1897 The thoracic derivatives of the posterior cardinal veins of swine. Bulletin of Museum of Comp. Zoöl., Harvard University, vol. 31, no. 6, pp. 133–144.

REAGAN, F. P. 1919 On the later development of the azygos veins of swine. Anat. Rec., vol. 17, no. 3, pp. 111–125.

REAGAN, F. P., AND TRIBE, M. 1927 The early development of postrenal vena cava in the rabbit. Proc. Anat. Soc. of Gr. Britain and Ireland. (In press.) Cambridge Univ. Press.

ROBINSON, A., AND REAGAN, F. P. 1927 The later development of postrenal vena cava in man. Proc. Anat. Soc. of Gr. Britain and Ireland. (In press.) Cambridge Univ. Press.

SABIN, F. L. 1915 On the fate of the posterior cardinal veins and their relation to the vena cava and azygos veins in pig embryos. Carnegie Institution of Washington, Publ. no. 223, Contrib. to Embryology, vol. 3, no. 7, pp. 5–32.

STRONG, L. H. 1925 The development of the azygos and cervical drainages with especial reference to the conditions of the rabbit. Thesis filed in the Library of the Univ. of California.

———— 1926 The dorsal aortic plexus, a factor in the development of body wall drainage in the rabbit. University of California Publ. in Zoöl. (In press.)

STRONG, M. T. 1925 The development of the azygos veins in Mus norvegicus. Thesis filed in the Library of the Univ. of California.

———— 1926 The derivatives of the posterior cardinal vein in the rat. Anat. Rec., vol. 31, no. 4, pp. 320–321.

ZUMSTEIN, J. 1897 Zur Entwickelung des Venensystems bei dem Meerschwein. Anat. Hefte, Bd. 8, pp. 165–190.